MILITARY MAP READING

for the

NEW ARMY

with an Appendix on

JUDGMENT OF DISTANCE

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NEW ARMY

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JUDGMENT OF DISTANCE.

by

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INTRODUCTION.

Ability to 'read' a map is an essential element of military education. It implies a knowledge of the map alphabet, viz., the conventional signs employed, an appreciation of the scale used, and facility in the art of picturing and reproducing the nature of the ground represented. For tactical purposes visualization of the region shown is vital, and it should be the aim of all map readers to acquire the art of sketching accurately, in three dimensions, the topography of the ground which, on the map, is represented in two dimensions. For this purpose the various map-makers in different countries provide means of representing heights; these are accompanied by symbols—the conventional signs mentioned above—which help in the reconstruction of actual territory.

All instruction in map-reading should aim at training the observer (a) to visualize correctly the nature of the surface features shown; (b) to discover his position in any region for which a map is provided; and (c) to proceed by night or day from a known point to any given objective pictured on the map.

The most comprehensive study of this subject is made in the Manual of Map Reading, Photo Reading and Field Sketching, published by the War Office in 1929. This present small volume is not intended to be anything other than a handbook for use in the field; those who wish to undertake a detailed study of the subject are referred to the War Office Manual, mentioned in the text by the abbreviation "M.M.R."

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MILITARY MAP READING.

2. USEFUL DEFINITIONS AND MEASURES.

Further explained in the main text.

Bearing—the angle, measured clockwise, between the True, Magnetic or Grid North line of the map and a line of observation. Note that there are therefore True, Magnetic and Grid bearings.

Contour—a line joining all points at an equal height above mean sea-level.

Contour or Vertical Interval (*V.I.*)—the difference in height between adjacent contours.

Gradient—a fraction which expresses slope, usually in terms or the rise or fall of one foot in a certain horizontal distance ; thus 1/10 equals a rise or fall of 1 foot in 10 feet.

Other current terms are explained in the text.

Measures—One mile equals 1,760 yds. (1,760x), or 5,280 ft. (5,280′), or 63,360 ins. (63,360″).

One kilometre (1 km.) equals 1,000 metres (1,000 m.).
equals 100,000 centimetres (100,000 cms.).
equals 1,000,000 millimetres (1,000,000 mms.).

One inch is roughly 2½ centimetres.

One kilometre is roughly 6/10 of a mile ; so, for rapid calculation to transform kilometres into miles, divide the number of kilometres by 10 and multiply the result by 6. Thus 40 kms. equals 24 miles.

3. THE ALPHABET OF THE MAP.

Most maps are supplied with a key devised to illustrate the material shown, e.g. roads, railways, churches, post-offices, telephones, etc., as well as natural features such as woods, rivers, lakes and so on. The symbols used in illustration are known as *Conventional Signs*. In addition, since a map is only a plan of the ground under survey, various devices are necessary to give information on relative and actual heights.

The *Conventional Signs* differ from country to country ; and some of the major types for maps issued by Great Britain, France and Germany are shown here. (See also M.M.R., plates 2 and 3).

Under normal conditions the signs shown on the accompanying sheets (figs. 1 and 2, pages 8–9 and 12–13) are fixed ; but for military purposes additional details are required, e.g. sites of batteries, searchlights, dugouts, trenches, headquarters, hospitals, observation posts, dumps and their type, etc. (See, for example, plate 6, M.M.R.). All such symbols are temporary and liable to alteration at the discretion of those in command of operations, such alterations being signified in routine orders.

It is obvious that the necessity to alter the current military symbols, which are overprinted on the peace-time maps, may frequently arise in order to avoid giving information to the enemy.

Knowledge of the normal and exceptional signs employed is the basis of map reading ; for only by complete understanding of these is it possible to form a mental picture of the field of operations. For ease of recognition the various symbols employed are generally as close a reproduction of the object, viewed from above or at a steep angle, as is possible ; trees are shown as if viewed from the side. The M.M.R. gives a

complete series of signs used in ground and aerial warfare, both for the published maps in use and for insertion on sketch maps prepared in the field (plates 2 to 6 inclusive, M.M.R.).

Some typical British, French and German Maps.

British. The most common British map is the one inch to one mile, 1/63,360, Popular Edition, published by the Ordnance Survey of England and Wales. On it relief is shown by orange-coloured contours at a vertical interval of 50 feet. alternate contours being marked, together with many spot-heights. Roads are distinguished according both to their surface and their width. Roads suitable for speedy traffic are coloured red ; ordinary traffic, yellow ; difficult for traffic, broken yellow ; and definitely bad, uncoloured. Footpaths are shown by dashed lines. **(Read above with a copy of the map before you).**

Railways, double or more tracks, are shown by a solid black line ; single track by a fine double line with broken black filling ; stations by circles. Fine black lines with bars across indicate mineral railways.

Woods and parks are usually coloured green.

Rivers and canals appear in blue, and are distinguished by the straightness of the latter and by a symbol for locks.

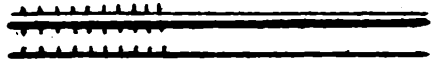
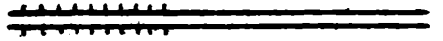
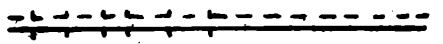
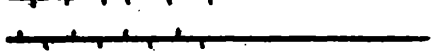
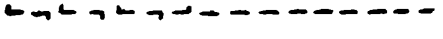
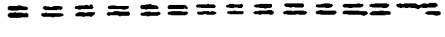
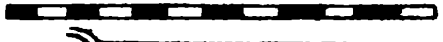
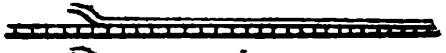
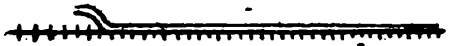
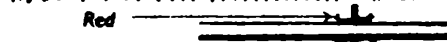
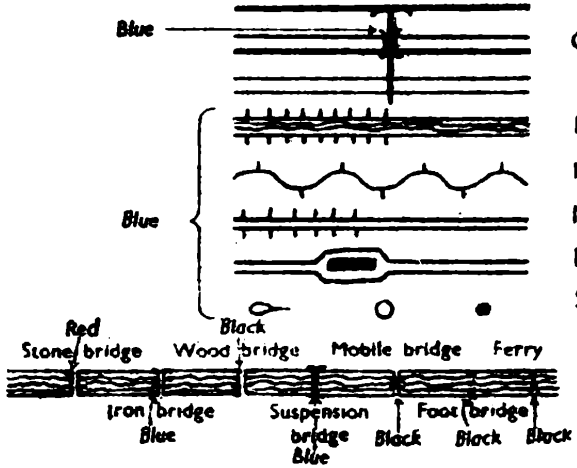
French. The 1/50,000 map has contours printed in brown at 10 metre intervals, together with spot-heights and hill-shading in brown, based on the idea of illumination of surface features from the north-west corner of the area shown.

Woods, meadows, orchards and gardens are shown by various shades of green.

Four grades of road fit for vehicular traffic appear with the approximate width of each in metres, shown in the key.

Water bodies are coloured blue, and there is a very full list of conventional signs attached—much more elaborate than on the British 1" Popular.

Conventional Signs used on 1/50,000 (France) together with French text and English equivalent

FRENCH	SYMBOL	ENGLISH
Routes et Chemins carrossables — Régulièrement entretenus: Route Nationale		Motor Roads — Well maintained: National Road
„ Dép^le et Ch^ins de G^de Communication		Departmental and Main Road
Ch^ins ayant au moins 6^m		Road at least 6^m wide
„ „ moins de 6^m		„ less than 6^m wide
Irrégulièrement entretenus		2nd Class Road
Chemin d' exploitation		Commercial Road
Sentier de piétons permanent		Major Footpath
Vestiges de voie ancienne		Remains of ancient road
Chemins de fer — à 4 voies		Railways — 4 tracks
à 2 voies		2 tracks
à 1 voie		1 track
à voie étroite		narrow gauge
Tramway		Tramway
Passages supérieur (pont en pierre)		Crossings — overhead (stone bridge)
„ inférieur („ „ fer)		underground (iron bridge)
„ à niveau		level crossing
Fleuve ou grande rivière		River falling into sea or major river
Rivière, ruisseau important		Minor river or major stream
Canal navigable, rivière canalisée		Navigable canal or canalised river
Port, écluse et maison d' éclusier		Dock, lock, lockhouse
Source, fontaine, puits		Spring, fountain, well
Passage de rivière		River crossings

Bois

Près

Vergers Jardins

Vignes

Eglise Chapelle isolée Croix

Ouvrages de Fortifications

Etablissement Industriel { mû par la vapeur / à moteur hydraulique / producteur d' électricité

Four à chaux Four à plâtre

Carrières de pierres de sables (à ciel ouvert)

„ „ „ „ „ (souterraines)

Bureau de Poste

„ „ „ et Télégraphe

„ „ „ „ „ et Téléphone

Limite d' Etats avec bornes frontières

„ dé Departements

„ d' Arrondissements

„ de Cantons

„ de Communes

Préfecture

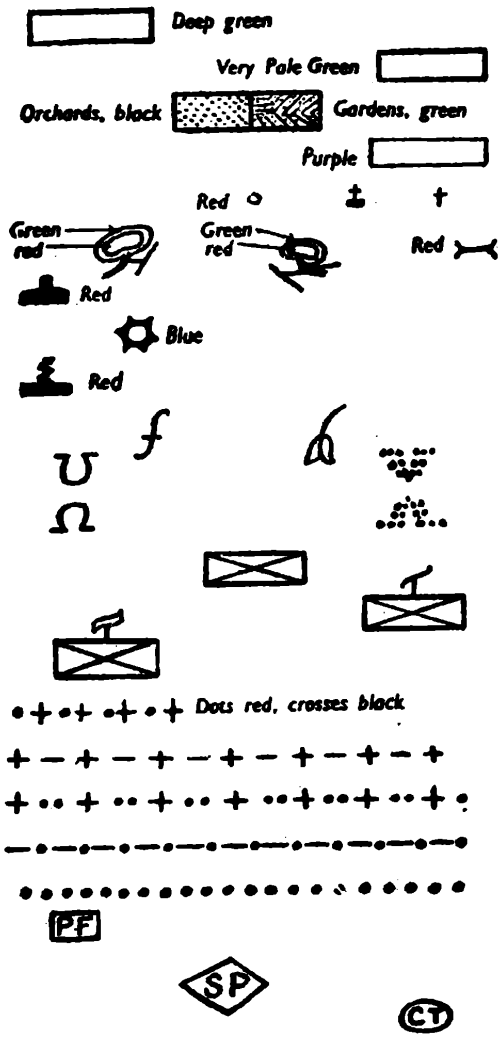
S^e Préfecture

Canton

Cables transporteurs de force électrique

„ „ d' exploitation

Moulins à vent à eau



Woods

Meadow

Orchards Gardens

Vineyards

Church Chapel Cross

Fortifications

Industrial establishments { steam driven / water / producing electricity

Lime and plaster kilns

Quarries—stone, sand (open)

„ „ „ (underground)

Post Office

„ and Telegraph Office

„ „ „ and Telephone Office

State Boundaries, with frontier posts

Departmental Boundary

Ward „

District „

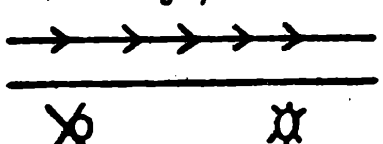
Parish „

Prefecture

Sub-prefecture

Canton

Minor differences of colouring are found on the Rural Sheets; but the text is the same. The following symbols also occur :—



Transport Cables—of electric power

„ „ commercial

Windmill Watermill

Fig. 1

German. The German 1/50,000 has a very detailed and complicated list of symbols. Relief is shown by brown contours at 10 metre intervals. It is not a very satisfactory map, as so much has been included that its details are difficult to follow. The same criticism applies to the 1/25,000 variety; and the fact that in both types most of the material is printed in black further obscures the matter portrayed.

Scales.

Every map represents an area of ground, but obviously upon a reduced scale. It is necessary to indicate upon a map or diagram the relation of measurements between points upon the map to the equivalent distances on the ground. This ratio between map and ground distances is known as the *Scale* of the map. For example, if two positions A and B are 1 mile apart on the actual ground and 1 inch apart on the map, the scale is such that 1 inch on the map represents 1 mile on the ground.

There are three methods of showing this relationship upon a map :—

1. By a statement in words; for example, 'one inch represents one mile,' or '6 inches represent 1 mile,' etc.
2. By what is termed a *Representative Fraction* (R.F.), e.g. 1/63,360, which means that one unit of measurement on the map represents 63,360 of the same units on the actual ground.
3. By a *Plain Scale.* This is a straight line divided and indicated to show what proportion distances on the map bear to the actual distances on the ground which they represent.

Of these three methods the most useful is the second, because it is broadly independent both of differences in language and varying units of measurement.

In Great Britain it is customary to divide the maps prepared by the Ordnance Survey into two groups, viz. :—

(a) *Large Scale*, on which a fairly large measurement upon the map, e.g. 6 inches or 25 inches, represents a mile on the ground.

(b) *Small Scale*, on which small distances on the map, e.g. 1 inch or ½ inch, represent a mile on the ground.

It follows that detailed outlines can be shown only upon Large Scale maps, which are consequently those most suitable for tactical operations. Small Scale types are those customarily used in major strategical plans.

Certain generalisations may be made about Scales and their use in maps hurriedly prepared in the field. They are :—

1. For reconnaissance, forward observation, establishing outposts and detailing attack, your map or diagram should be between 1/25,000 and 1/50,000. The same applies to positioning advance posts and to all local skirmish.

2. For military activity in towns and cities a larger scale is desirable, say 1/10,000 to 1/20,000. This is useful for establishing camps, billets, etc.

The French favour three maps, one for general purposes, viz., the 1/200,000, and two for tactical purposes, viz., the 1/80,000, which is a fairly large scale, or the 1/50,000, which is especially suitable for more detailed operations.

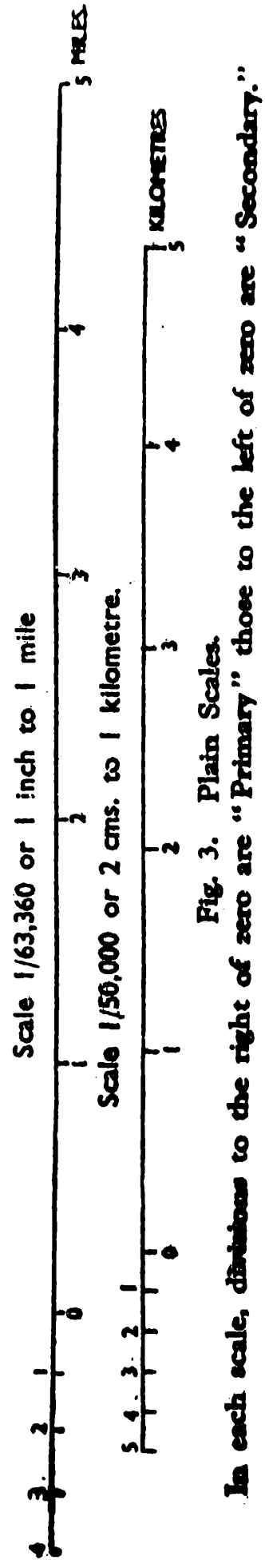
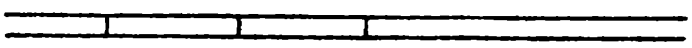
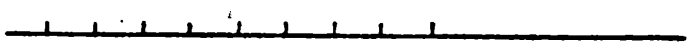
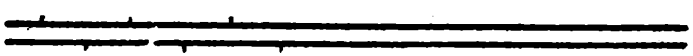
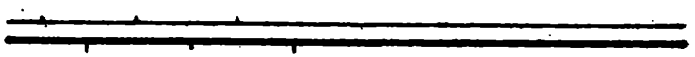
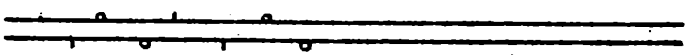
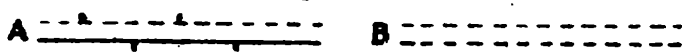
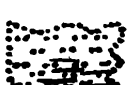


Fig. 3. Plain Scales.
In each scale, divisions to the right of zero are "Primary" those to the left of zero are "Secondary."

Conventional Signs used on 1/25,000 (German) together with German text and English equivalent

GERMAN	SYMBOL	ENGLISH
Eisenbahnen.		*Railways.*
mehrgleisige Haupt-u vollspurige Nebenbahn.		double-track main line, full gauge.
eingleisige Haupt-u vollspurige Nebenbahn.		single-track main line, full gauge.
vollspurige nebenbahnmässi Kleinb.		full-gauge siding.
Strassen u. Wirtschaftsbahn.		Tramway. commercial line.
Strassen.		*Roads.*
etwa 5.5m. Mindestnutze breite.		at least 5.5m. wide. always passable.
etwa 4m. Mindestnutze breite.		at least 4m. wide. not always passable.
unterhaltener Fahrweg.		bus road. good surface.
A. Feld B. Waldweg.		A. bridle path. B. ride.
Mischwald.		wood (mixed) or forest.
Heide u. Odland.		heath and wasteland.
Sand oder Kies.		sand or dunes.
Wiese (nasse Wiese).		pasture (meadow).

Bruch mit Torfstich

Weingarten.

Bruchfeld.

A Grube. B Steinbruch.

A Kapelle. B Hohenpunkt.

A Kilometerstein. B Niv. punkt.

Kirche.

A Bergwerk. B Trig. punkt.

Wassermühle. Wasserturm.

Windmühle.

Abkurzungen.

Bhf. Bahnhof.
Fabrik.
Kaserne.

Gewasser.

Strom. A Holzbruke. B Eisernebruke. C Steinbruke.

Kanal. Schleuse.

See. Insel.

Nasser gruben.

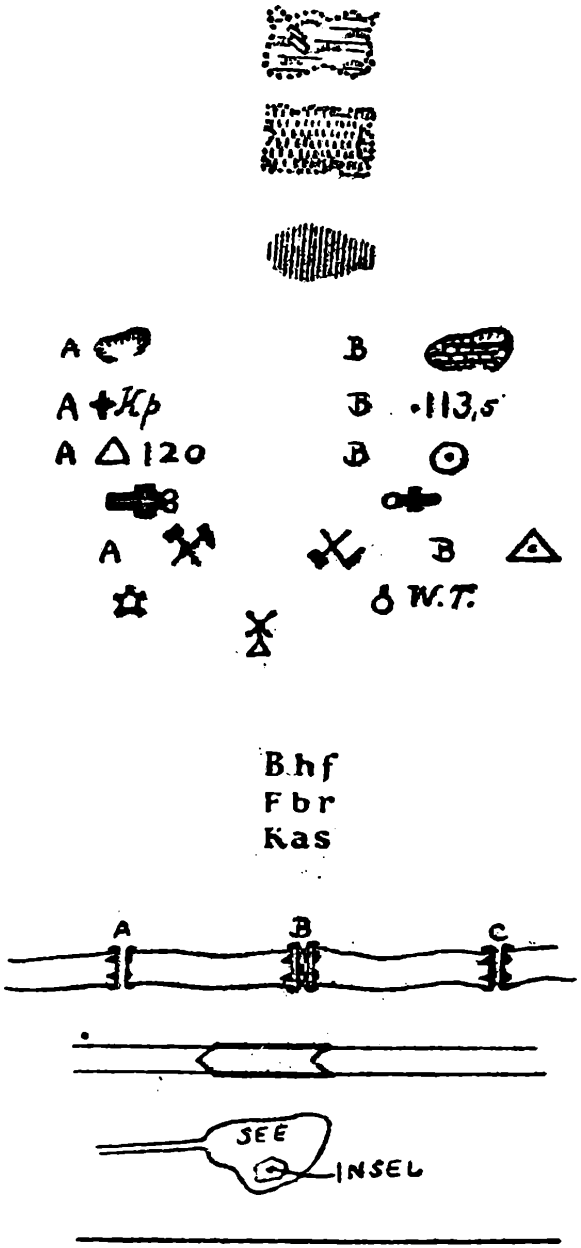


Fig. 2.

bog. peat-cutting.

vineyard.

marsh.

A surface mine. B quarry.

A chapel. B spot height.

A kilometre stone. B level point.

church.

A mine. B Trig. point.

watermill. water tower.

windmill.

Abbreviations.

station.
factory.
barracks.

Water.

river. wooden bridge. iron bridge. stone bridge.

canal. lock.

lake. island.

wet ditch.

EXAMPLES.

Example 1.

Given a scale of 3" to one mile, what is the R.F. ?

First discover how many inches of ground is shown by one inch on the map.

3 inches represent one mile $= 63{,}360$ *inches.*

$\therefore$ *1 inch represents one-third mile* $= \frac{63{,}360}{3}$ *inches.*

$= 21{,}120$ *inches.*

$\therefore$ R.F. *is* 1/21,120.

Example 2.

Given that scale is 3 miles to one inch, what is the R.F. ?

1 inch represents 3 miles $= (3 \times 63{,}360$ *ins.*$) = 190{,}080$ *ins.*

$\therefore$ R.F. *is* 1/190,080.

Example 3.

Given that R.F. is 1/150,000, what is the scale in miles to the inch ?

1 unit on the map represents 150,000 units on the ground.

Thus 1 inch on the map represents 150,000 ins. on the ground.

$$= \frac{150{,}000}{63{,}360} \text{ miles} = 2.367 \text{ miles.}$$

$\therefore$ *Scale is 2·367 miles to the inch.*

(*It is usually sufficient to go as far as the nearest second place of decimals.*)

Example 4.

Given a French map of scale 1 centimetre to represent 2 kilometres, what is the scale in inches to the mile?

Since 2 kms. = 200,000 cms.
R.F. of map is 1/200,000.

$\therefore$ *200,000 ins. would be represented by 1 inch.*

$\therefore$ *1 in. would be represented by* $\frac{1}{200,000}$ *inch.*

$\therefore$ *1 ml. (63,360″) would be represented by* $\frac{63,360}{200,000}$ *inches.*

$= .315$ *ins.*

$\therefore$ *Scale is .315 inches to the mile.*

To Construct a Plain Scale.

Problem. You are required to construct a scale of 3 inches to one mile, showing divisions of 100 yards.

It is clear that 3 inches represents 1 mile, i.e., 63,360 inches.

Therefore the Representative Fraction is 3/63,360.

$= 1/21,120.$

A scale line should be between 4 and 6 inches in length.

4 inches would show $1\frac{1}{3}$ miles = about 2,350 yds.

6 inches would show 2 miles = about 3,520 yds.

Select a fairly large round number between these limits, say 3,500 yards.

Length of scale will be $\frac{3,500}{21,120}$ yds. $= \frac{3,500 \times 36}{21,120}$ ins.

$= 5.96″.$

or

Yds. in ml. : Yds. in scale = Ins. rep^{g} ml. : Length in ins. of scale.

Draw a line 5.96″ long and divide into 7 equal parts. Each represents 500 yds. Subdivide left section into 5 parts, each representing 100 yds.

The larger divisions are known as *Primary* divisions, the smaller as *Secondary* divisions. When possible the Plain Scale should show distances which are multiples in tens, hundreds or thousands of the unit of measure, whether it be a foot, yard, mile, centimetre, metre or kilometre. In all cases a decimal division of the line is desirable—into tens, hundreds, etc.

One of the most important forms of scale for a mechanised unit or one otherwise mobile is the 'TIME SCALE,' whereby the distance travelled may be quickly ascertained from the time taken—given an average speed of marching or driving.

Example. To construct a Time Scale for a unit moving at 24 miles per hour and using a map of 2 miles to one inch.

Now one inch represents 2 miles, therefore 6 inches represents 12 miles, which will take half an hour.

Draw a line 6 inches long and divide it into six equal parts.

Each part will represent two miles movement and five minutes time. Subdivide the left hand division for one minute intervals (equals 705 yards travel).

4. THE REPRESENTATION OF RELIEF.

The relief or shape of the land surface can be shown in several ways, sometimes by a combination of two or three methods. On all modern maps the two most important are shown together—spot heights and contours.

Spot Heights. Nearly all large scale maps have numbers inserted at many points to indicate the height above sea level of the ground at each point. More often than not spot-heights are for summits rather than for the bottoms of

depressions. On English maps the height is measured in feet; on French and German in metres. (Where, on an English map, the number has "B.M." written alongside, it refers to the height above sea level of the bench mark on a building, which is usually about two feet above the surface of the ground.) Spot-heights are useful because they are accurately measured. They cannot, however, give any impression of the relief over the greater part of the map; and to show this other methods are necessary.

Hachures. Some maps employ 'hachures'—short wavy lines drawn roughly parallel to each other down the slopes in the direction in which water would flow, so that the steeper the slope the closer together are the lines and the more heavily they are printed.

Hill Shading. More frequently shading is used, as on the French 1/50,000, so as to give the eye an impression of the differences of relief. (The shading is really 'stippling,' being composed of many small dots.) A steep slope is shaded heavily and a moderate slope lightly, and fairly level surfaces like plateau tops and valley bottoms are left white. In most instances when hill shading is employed, it is designed so as to appear as shadows resulting from a light to the N.W., i.e., on a N.-S. ridge the eastern slope would appear in darker shading than the western slope (as on the French 1/50,000). Both hill shading and hachures, however, give merely an impression of the relief, and are not at all accurate, being at times even misleading.

Contours. Contours are now employed on nearly all maps, and can be interpreted to obtain a view of the relief which will be uniformly accurate except for small details. A contour is a line joining a number of points which are at the same height above sea level: on the map it appears as a continuous

line, being coloured orange on English maps, brown on French and being a faint black line on the German. (If all the spot-heights for say 100 feet, were joined up, the result would be a contour.)

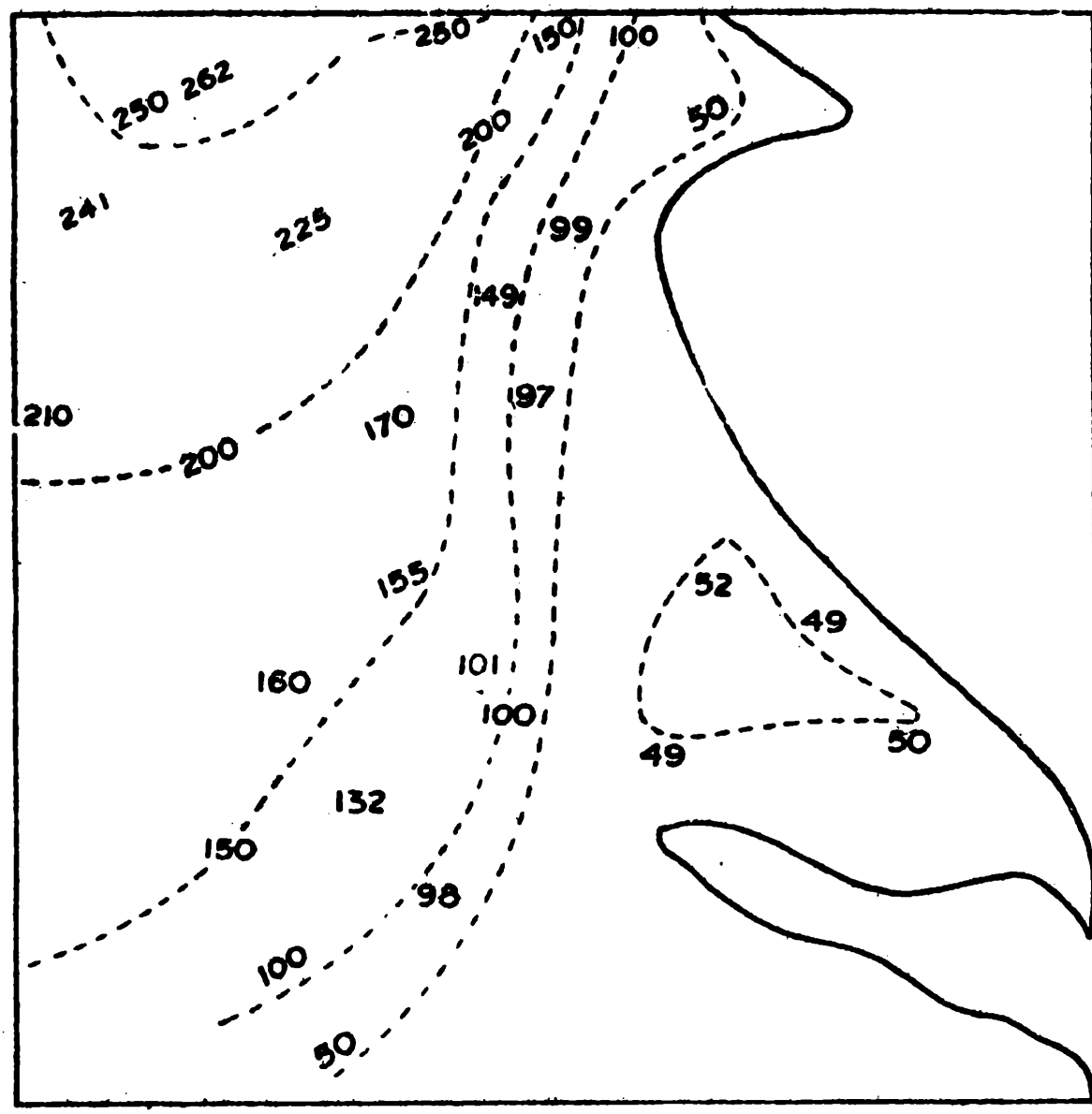


Fig. 4.
Contour lines for 50, 100, 150, 200 and 250 feet.

The first contour is drawn at some convenient height above sea level, 50 feet in the British 1", 10 metres on the French 1/50,000 and 20 metres on the German 1/25,000; and the succeeding higher contours are usually drawn at the same intervals. This

vertical distance between two contours is called the Vertical Interval, or V.I. ; on the English 1" the V.I. is 50 feet, on the French 1/50,000, 10 metres, and on the German 1/25,000, 20 metres between the heavy contours and 10 metres between the heavy and light contours. The actual height above sea level is indicated on English maps by a number, either on the line or just above it ; on the German maps the number for each contour appears in the margin ; on the French large scale maps the contours are not numbered, and reference has to be made to the spot heights, large numbers of which are inserted.

Gradients.

It will be seen from Fig. 5 that the stretch of gentle slope AB appears on the map with contours widely spaced, and that CB, the steep slope, appears with contours close together. This relation between slope and contour is universally true, so that by noting the spacing of the contours the slopes anywhere on a map can be estimated and compared. Where two or more contours touch each other for any distance, it is clear that a cliff or precipice exists. (It may be assumed that the slope is even between one contour and the next, e.g. a point above the 400 foot contour one quarter of the distance between this and the 500 foot contour would be at a height of 425 feet.)

The distance on the map between one contour and the next is called the Horizontal Equivalent, or H.E. By noting this it is possible to calculate a gradient, which is always expressed as one unit of the rise in so many units of the horizontal, e.g. 1 in 10. It is obtained by dividing the V.I. by the H.E., i.e. difference in height over distance on the ground. Suppose that on a map of the scale 1" to 1 mile, on a certain stretch of a road which ascends a ridge, the contours 1,000, 950, 900, 850, 800, 750, 700 come close together, suggesting a

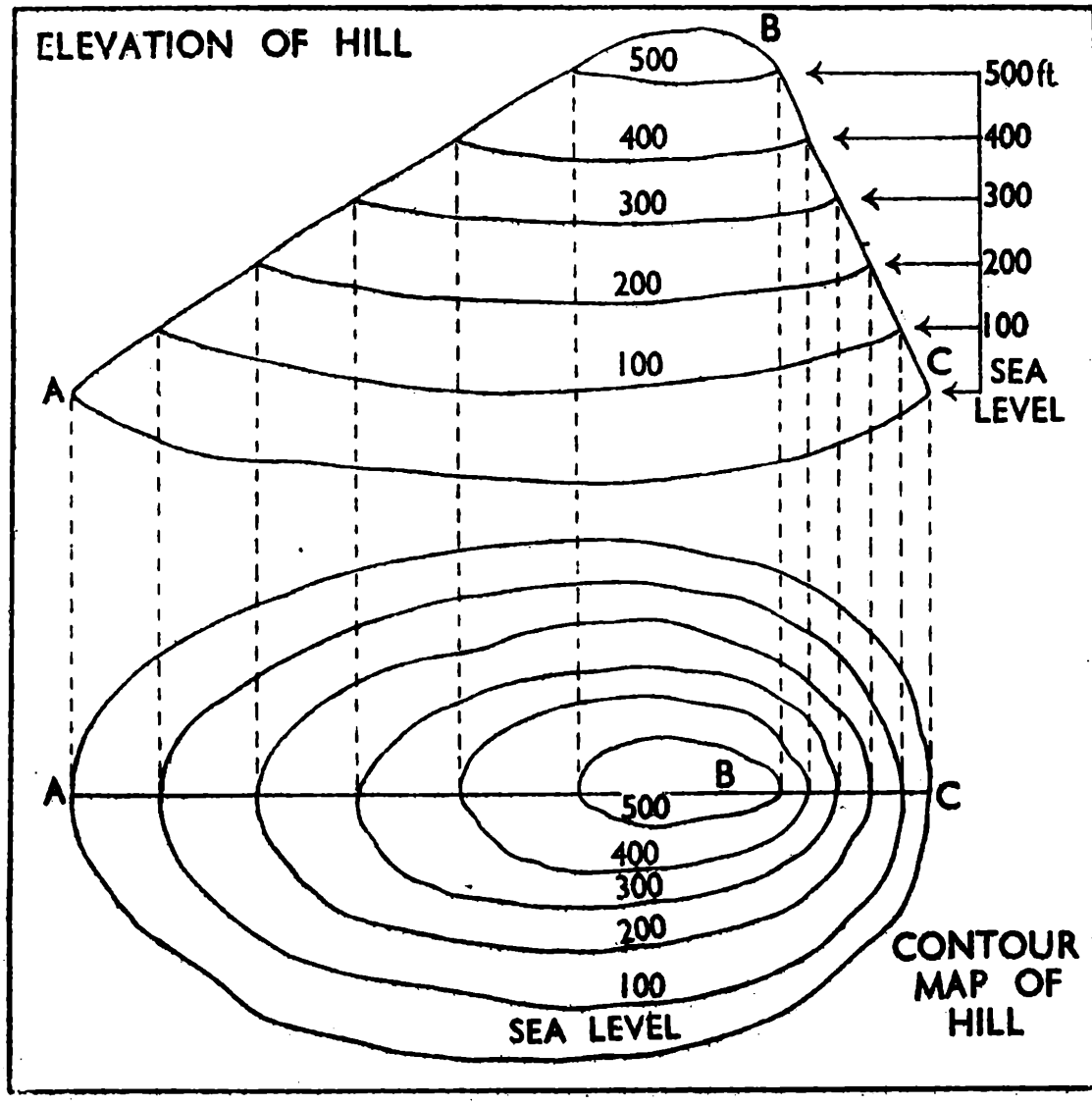


Fig. 5.

steep hill, and that the distance between the 1,000 and the 700 contours is ½". Subtract the height of the lowest contour from that of the highest (giving 300 feet); scale off the distance between them on the road (½" on 1" to the mile equals 2,640 feet); $\frac{\text{Vertical difference}}{\text{Distance on ground}}$ $\frac{300,}{2,640}$ approx. $\frac{1}{9}$ i.e. the gradient is about 1 in 9. If, of course, spot-heights happen to be entered for the top and bottom of the hill, reference need not be made to the contours. As long as the

same units are employed in any one calculation, i.e. feet and feet, or metres and metres, the gradient can be worked out no matter what units are used on the map. Thus if a piece of road a kilometre long rises 200 metres, the gradient will be $\frac{200}{1{,}000}$ or 1 in 5.

Contours and Map Reading.

It will be observed that contours always take up a V shape where a river valley appears, with the V's pointing upstream. After some practice it becomes possible to acquire, from the contours, some idea of quite small changes of slope or low undulations such as would occur on a plain or plateau surface.

It must be remembered that a contour map will not show most small irregularities of the ground which stand above the surrounding surface at a height which is less than the V.I. of the contours.

Intervisibility.

It is important to be able to tell from a map what ground can be seen from a given point of observation before one arrives at that point. Sometimes it is fairly clear : thus in the small map A (fig. 6) an observer on the high ground in the west would be able to see the wood and the ground in between : the contours near him are closer, and the slope is therefore steeper than it is lower down towards the wood, i.e. the slope is concave. On the other hand, an observer on the higher ground to the west of the country shown in map B would not be able to see the wood or much of the intervening ground (which is " dead ground ") : the ground slopes more steeply near the wood, making the surface convex. Where contours are evenly spaced the slope would be uniform, and one could just see down the slope—but there would be some doubt, as any small irregularity in the ground or group of trees would obscure the view.

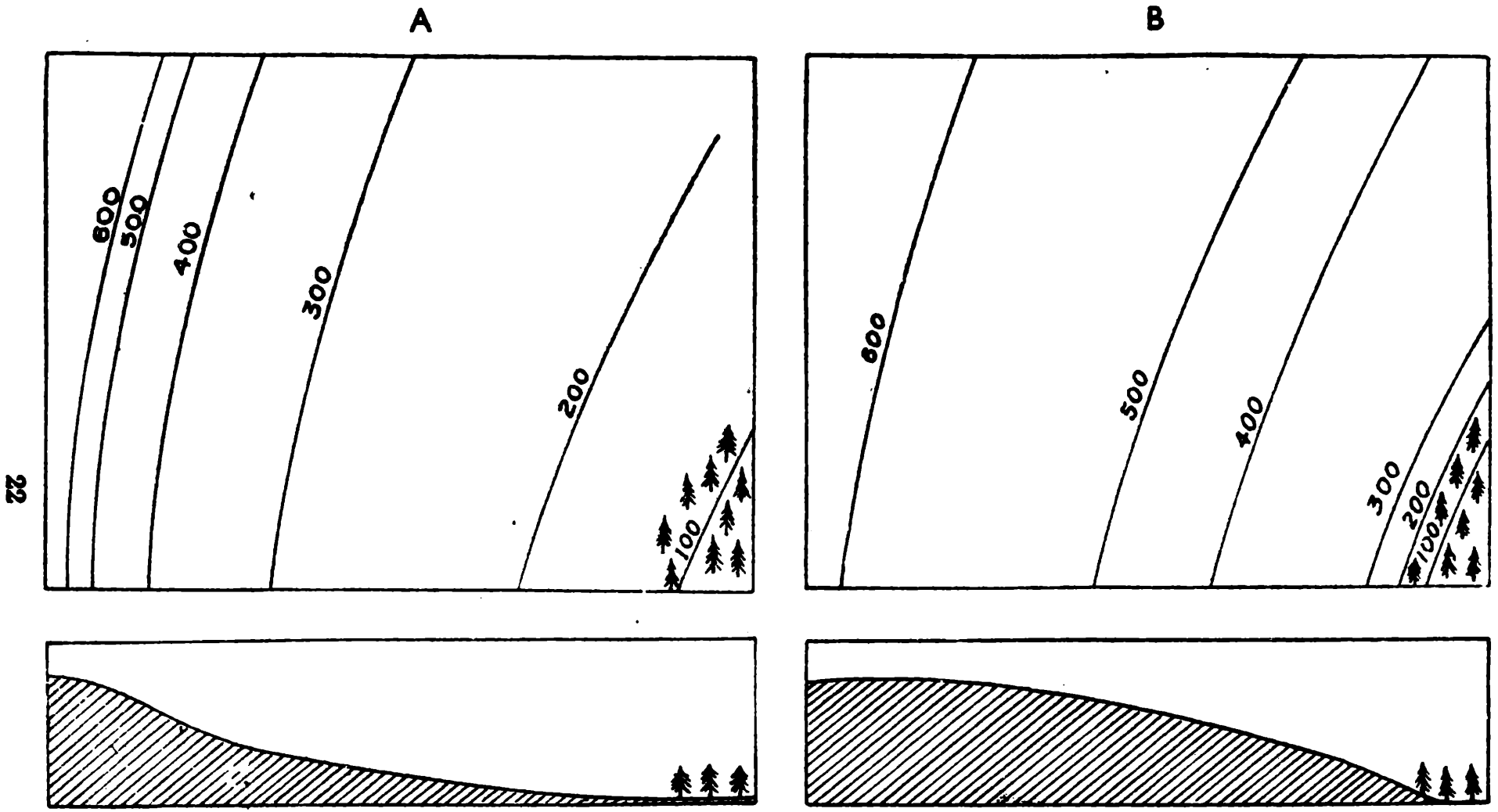


Fig. 6.

Wood at 100 feet visible from a height of 600 feet.

Wood at 100 feet *not* visible from a height of 600 feet.

Where the lay-out cannot be grasped by a simple inspection of the contours, some sort of test must be carried out. There are really two different problems which might occur, according to circumstances :—

1. To determine whether a given point is visible from a point of observation.
2. To map the area of ground which will be invisible to an observer at a given point.

Methods of Solving Problem I.

(a) By a short calculation.

It is required to determine whether from A, 400′ above S.L., a point C, 250′ above S.L. and 1,800 feet away, is visible, there being a point B which is in line, 325 feet above S.L. and 1,500 from A.

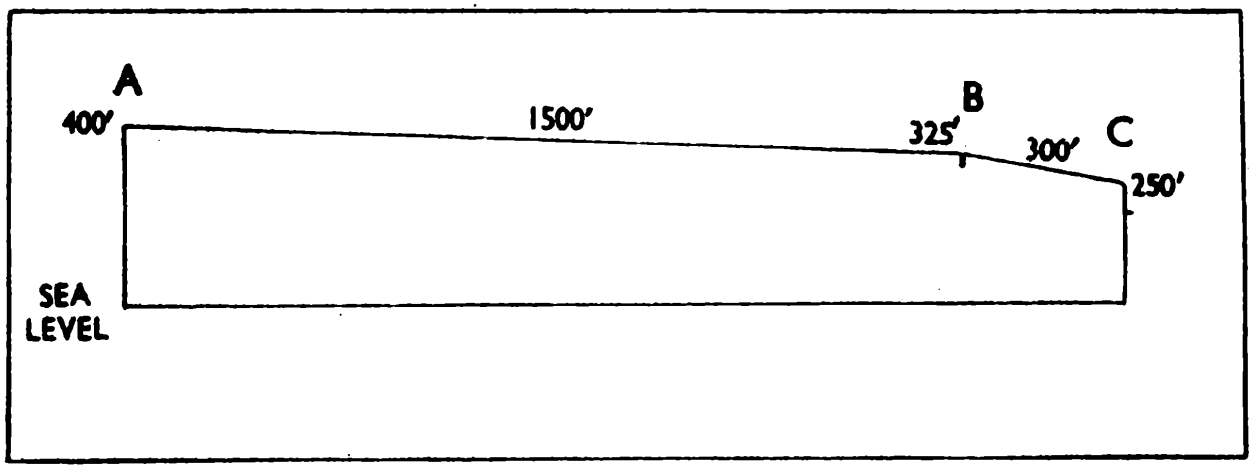


Fig. 7.

Call the difference in height between A and B, a : this is 75′.
Call the difference in height between B and C, b : this is 75′.
Call the difference in distance from A to B, c : this is 1,500′.
Call the difference in distance from B to C, d : this is 300′.

Then if $\frac{a}{b}$ is less than $\frac{c}{d}$ the slope is convex and there is no visibility : this is true here : $\frac{75}{75}$ or $\frac{1}{1,}$ being less than $\frac{1,500}{300}$ or $\frac{5}{1.}$

(If $\frac{a}{b}$ is greater than $\frac{c}{d}$ the slope is concave and C would be visible ; if $\frac{c}{b}$ equals $\frac{e}{d}$ the slope is uniform.)

(b) By constructing a simple diagram.

Draw a line AC to represent the distance, to scale, from A to C and mark B. At A, B and C draw vertical lines to represent the height above sea level at these points. (The scale at the verticals need not be the same as that of the map, and it is generally advisable to take a scale of 1 inch to 500 feet or so, in order to avoid awkward fractions.) By joining the tops of the verticals at A and C, it is possible to see whether the vertical at B obscures the view or not. In

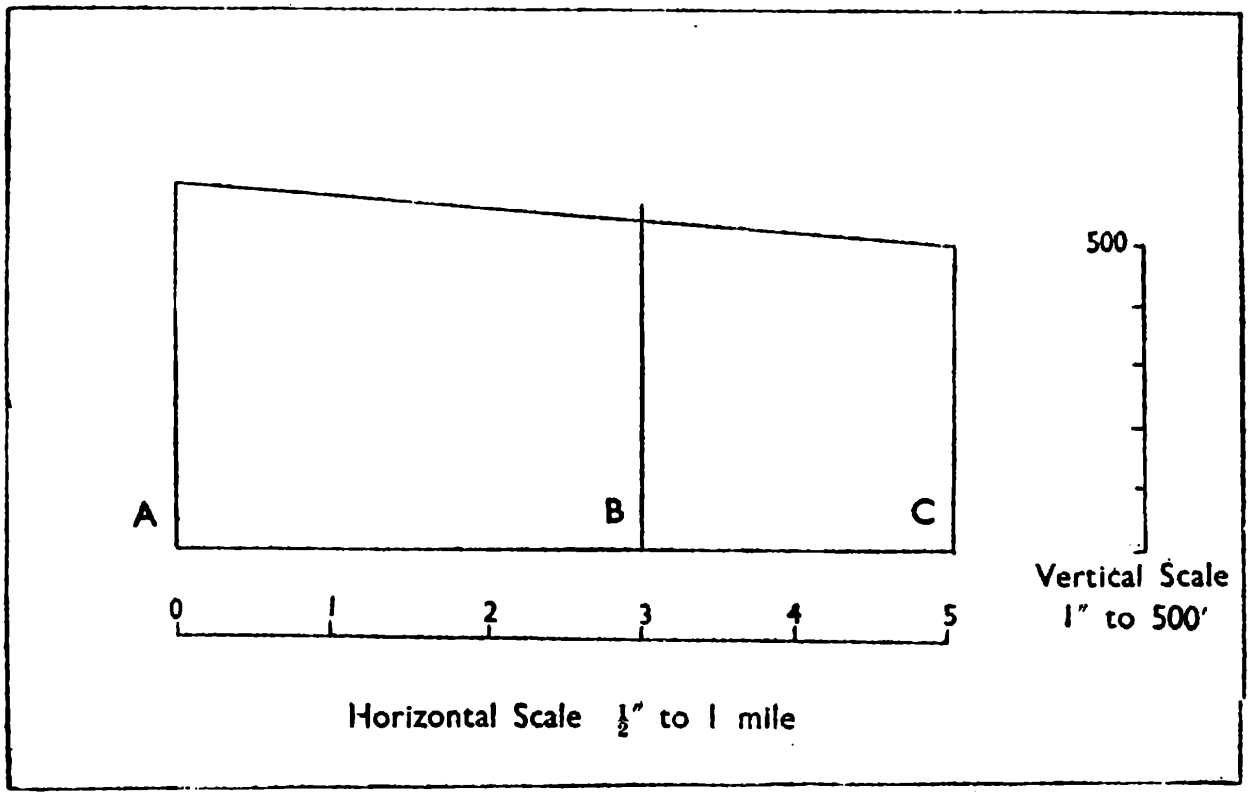


Fig. 8.

this example the position B was 550 feet above sea level, between A at 600 and C at 500, and lying 3 miles from A and 2 miles from C. The top of the vertical at B stands just above the line of sight joining the tops of those at A and C, and therefore obscures the view.

(c) By drawing a section, a more lengthy process, and not generally necessary. Draw a line to represent the distance from the point of observation to the point to be observed, and erect verticals at each end ; on each vertical mark divisions to correspond with the contours on the map, according to such a scale as that suggested above ; number these divisions as the contours are numbered, and join by a horizontal line each division

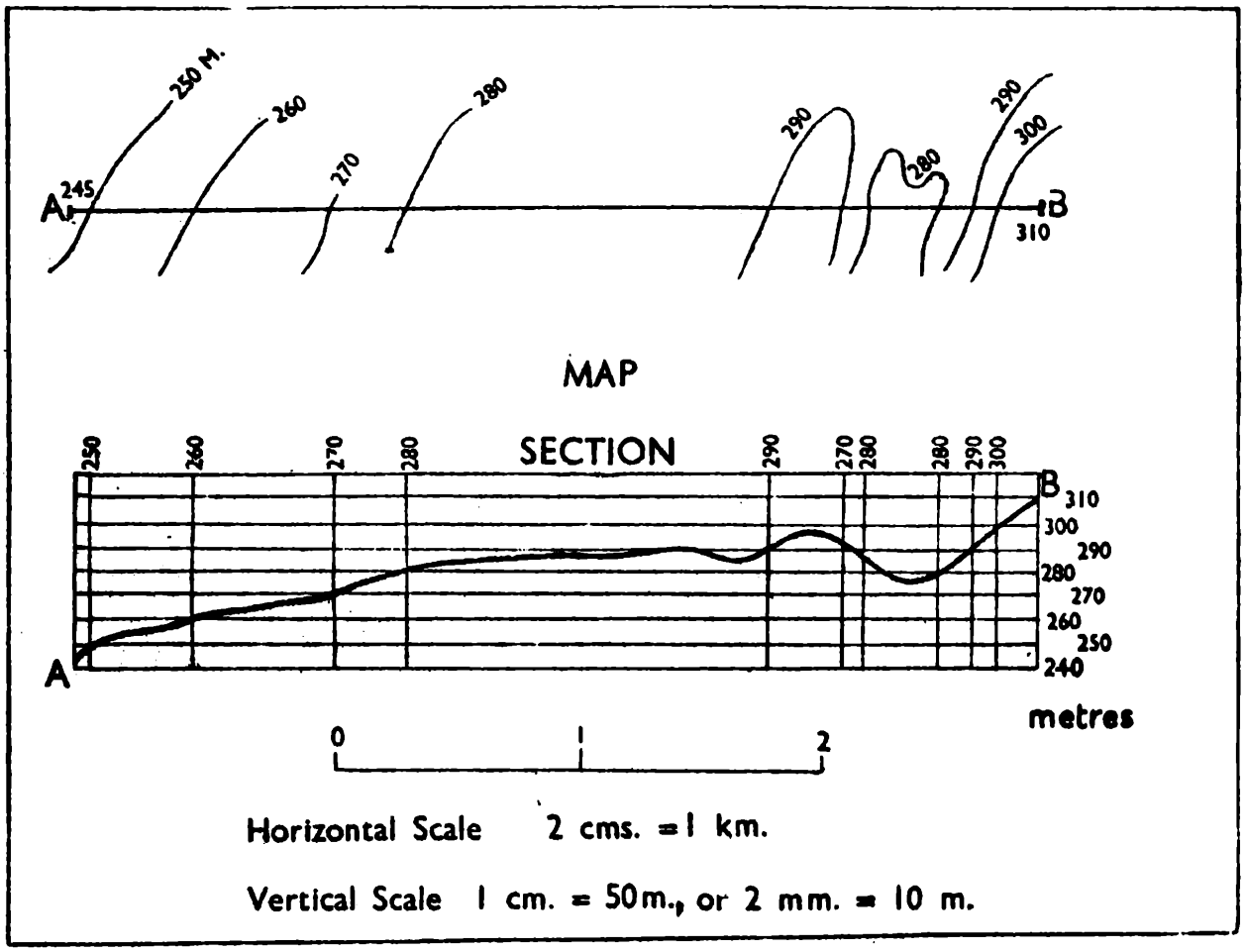


Fig. 9. A Section.

By laying a ruler from A to B on the Section, it can be seen that A is invisible from B.

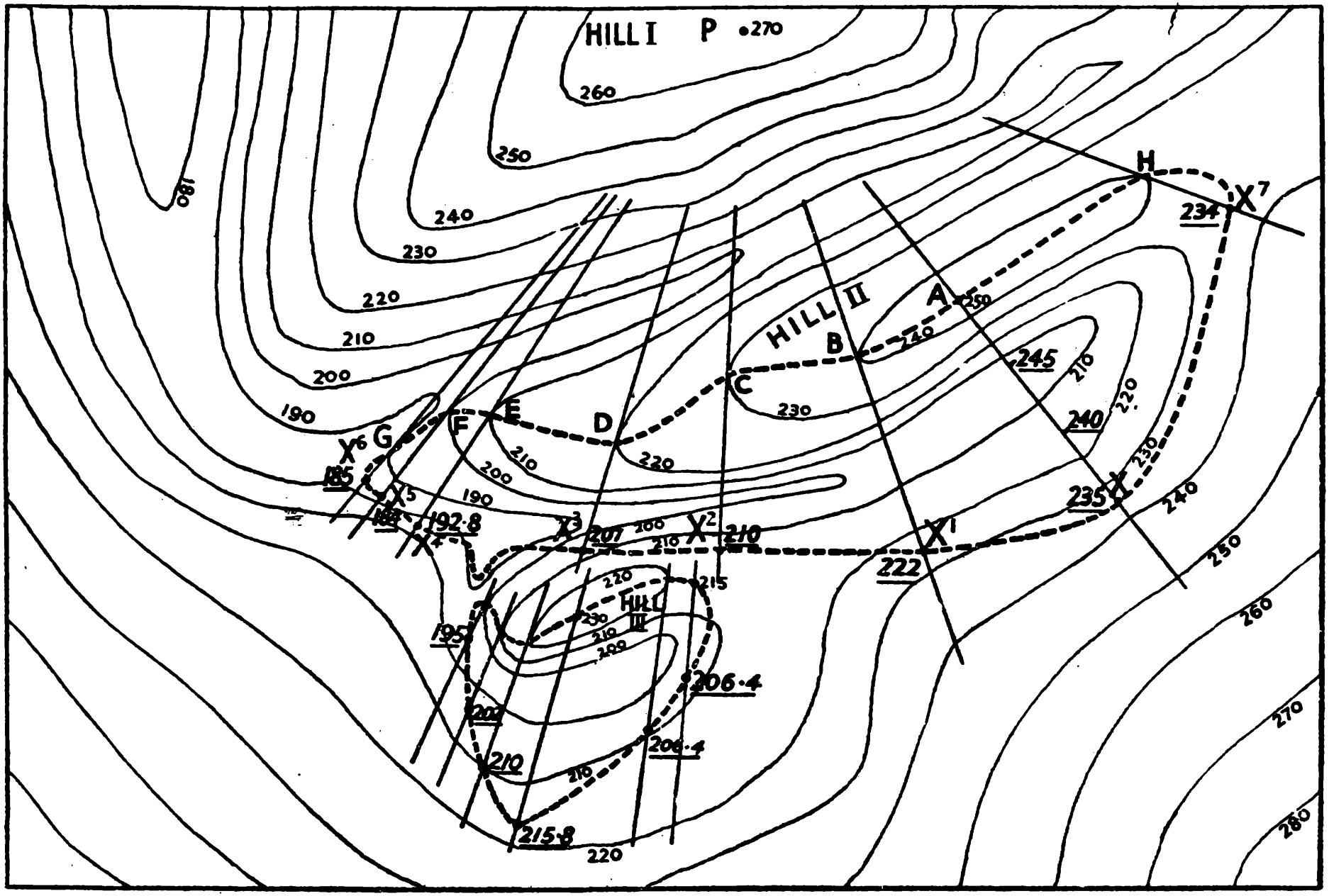

HILL I P ·270
HILL II
HILL III
A
B
C
D
E
F
G
H
X1
X2
X3
X4
X5
X6
X7
180
190
200
210
220
230
240
250
260
270
280
234
245
240
235
222
210
207
192·8
195
206·4
206·4
215·8
215

Fig 10. VISIBILITY DIAGRAM.

(Explanation.)

Scale—1/50,000.

2 cms. to 1 km.

The dead ground, or area invisible to an observer at P owing to the obstruction of HILL II., lies within the dotted line, A B C D E F G $X^6X^5X^4X^3X^2X^1X$ X^7H ; the area invisible owing to the obstruction of HILL III. lies within the other dotted line. (*There will be other dead ground, e.g. west of P, but this has not been determined.*) The figures for the smaller area of dead ground are shewn on the map, although the calculations are not given in the text.

All heights are shown in metres. Contours and spot heights are numbered but the height of points on the lines of sight is shown by numbers which are underlined thus 235.

(In any sheet of a French 1/50,000 map the contours would not be numbered as they are in this example.)

and its opposite number. (The horizontal line is generally made to represent a height equal to that of the contour below the lowest contour on the line joining the two points on the map.) Then lay a strip of paper along this line and mark on its edge wherever contours cross, numbering each mark accordingly ; then transfer the strip to the drawing, and mark on each horizontal the point at which a contour is marked on the strip, according to the appropriate number of the contour. Join up these points by a smooth line, and the result is a section of the ground all the way between the point of observation and the point to be observed.

Method of Solving Problem 2.

To map the area which will be dead ground to an observer at point P on Hill I., at 270 m., overlooking Hill II. and Hill III. (This example is taken from an imaginary French map ; the method would be exactly the same with an English map, feet and inches being used.)

Hill II. Draw a line from P through A, the highest point on Hill II., viz., 250 m., and continue it for some distance. This is the line of sight dropping from P ; AP is found by measurement to be 4 cms., i.e., the line drops from 270 m. to 250 m., or 20 m. in 4 cms., or 5 m. in 1 cm., so that 1 cm. beyond A it will be at 245 m., 2 cm. beyond at 240 m. At this point it will be seen from the contours that the ground is about 215 m. ; it is therefore below the line of sight, i.e., still invisible. The method is simply to measure along this, as along any line of sight, calculating its fall, until a point is reached where the fall brings the line of sight just at or below the height of the ground there ; the ground is now just at or above the line of sight, and therefore becomes visible. Continue measuring along this line PA for 1 cm. further ; the line will drop to

235 m., at which point it can be seen that the ground is at 235 m., and therefore visibility begins here at X. Repeat the process with PB, which is 4 cm., B being 240 m., so that this line drops 30 m. in 4 cm., or 7.5 m. in 1 cm. ; 2 cm. beyond it would be at a level of 240–15 or 225 m., which would be too high, for the ground there is under 220 m., but 4 mm. farther again the level will be .4 of 7.5 m. or 3 m. lower, i.e., 225–3 or 222 m. where the ground is 225 m. ; visibility therefore begins here at X1.

Again, with PC, dropping 40 m. in 4 cm. or 10 m. in 1 cm. ; 2 cm. beyond, the level is 230–20 m. or 210 m., at which point, X2, the ground is about 212 m., and therefore visible. PD drops 50 m. in 5 cm. or 10 m. in 1 cm., so that 1.3 cm. beyond D, at X3, the level is 220–13 or 207 m., the ground here being about 208 m. PE drops 60 m. in 5.25 cm. or 11.5 m. in 1 cm., thus 1.5 cm. beyond E, at X4, the level is 210–17.2 or 192.8 m., at which point the ground is 195 m. PF drops 70 m. in 5.5 cm. or 12.8 in 1 cm., so that 1.25 cm. beyond F, at X5, the level is 200–16 or 184 m., the ground being 185 m. PG drops 80 m., in 6.4 cms. or 12.5 m. in 1 cm., so that 4 mm. beyond G, at X6, the drop is a further .4 of 12.5 m. or 5 m., i.e., to 185, where the ground is 185 m. Finally X7 on the line PH is found to limit the invisible ground on the other side of A.

Draw a continuous line to join A, B, C, D, E, F, G, X6, X5, X4, X3, X2, X1, X, X7, H ; it is only ground outside that area which is not obscured by Hill II.

It will be clear that Hill III. will obscure some ground ; this is determined in exactly the same way by drawing lines from P as shown on the map and making similar calculations. The area shown will be invisible from P.

We have now determined all the dead ground for the observer at P which is caused by Hill II. and Hill III. ; any other dead ground would remain to be ascertained.

5. INSTRUMENTS.

1. *The Service Protractor.*

The protractor shows several scales on the front ; and on the back are other scales together with a diagonal scale for hundredths of an inch. The protractor proper consists of the graduation in degrees along three edges of the front face ; there are two sets of figures—from 0° to 180° on the outside edge, and from 180° to 360° on the inside. The fourth face is called the zero edge.

(All bearings are measured in a clockwise direction, reading from north by east, through south by west back to north.)

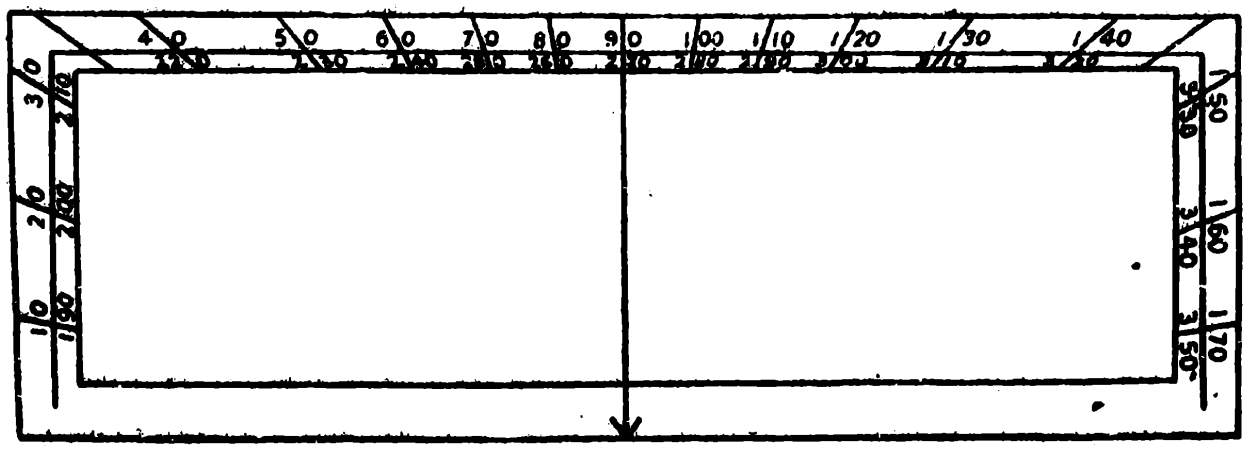


Fig. 11. Service Protractor.

To Plot or 'Lay Off' Bearings with the Protractor from a given point X. Draw a line through X to represent North —grid or magnetic, according to the north with which you are working. For any bearings up to 180°, say 140°, lay the protractor on the right of the line, with the zero edge against it and the arrow against X. The bearing may then be marked off by a point P at 140° on the outer scale. For any bearing from 180° to 360°, say 260°, proceed as before but lay the protractor to the left of the line and mark R at 260 on the inner scale. XP and XR are the required bearings plotted.

The Military Manual points out that it is not always necessary to draw a north line. If north lines are already on the map, e.g. meridian (or grid lines), lay the protractor with the arrow at X, so that the north line which is being used cuts the top and bottom edges of the protractor at graduations symmetrically placed.

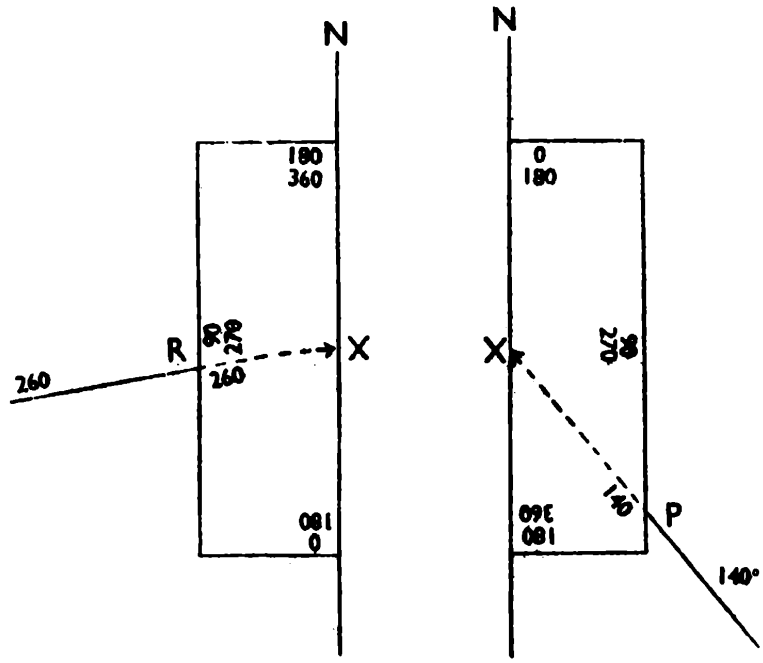


Fig. 12.

Bearings at 140° and 260° plotted with a protractor.

To Read Bearings with a Protractor.

This is the reverse process to setting off bearings. To read the bearing of X from A : join AX, set the protractor to the right of A, with the arrow at A and zero edge parallel to a north line, and read the bearing where the line AX cuts the outer graduated edge of the protractor. To read the bearing of Y from A, proceed as before, setting the protractor to the left of A and reading from the inner graduated circle.

2. *Service Prismatic Compass (Dry Type.)*

Open the compass by means of the nail clip and place the cover in an erect position. A hair-line will be seen running vertically across the glass window. The compass card will be seen to have an outer and an inner scale, the outer scale being graduated to one degree, the inner scale to five degrees. When the check stop is pushed, the compass needle and card are

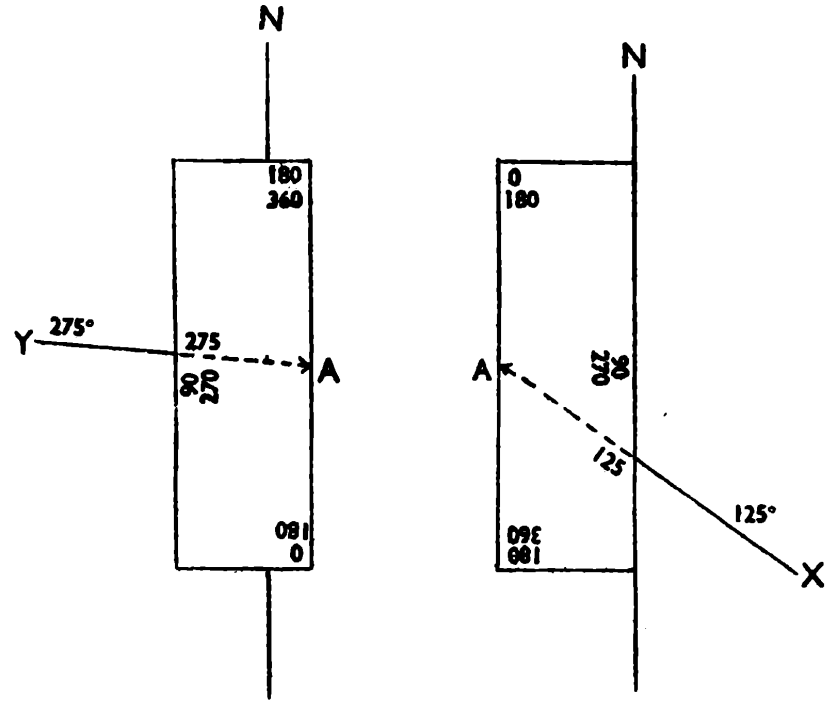


Fig. 13.

Reading bearings with a protractor.

The bearing at X from A is found to be 125°, the bearing at Y from A 275°.

released and will swing until coming to rest. (When the compass is not in use, the stop should be pushed back so that the card is stopped from swinging. When the compass is closed, the cam dip on the cover automatically pushes back the stop.) Tilt the prism casing so that the face is flat on the glass of the compass : the eye-hole and sighting slot are now visible. The prism now has to be focused to give a clear image

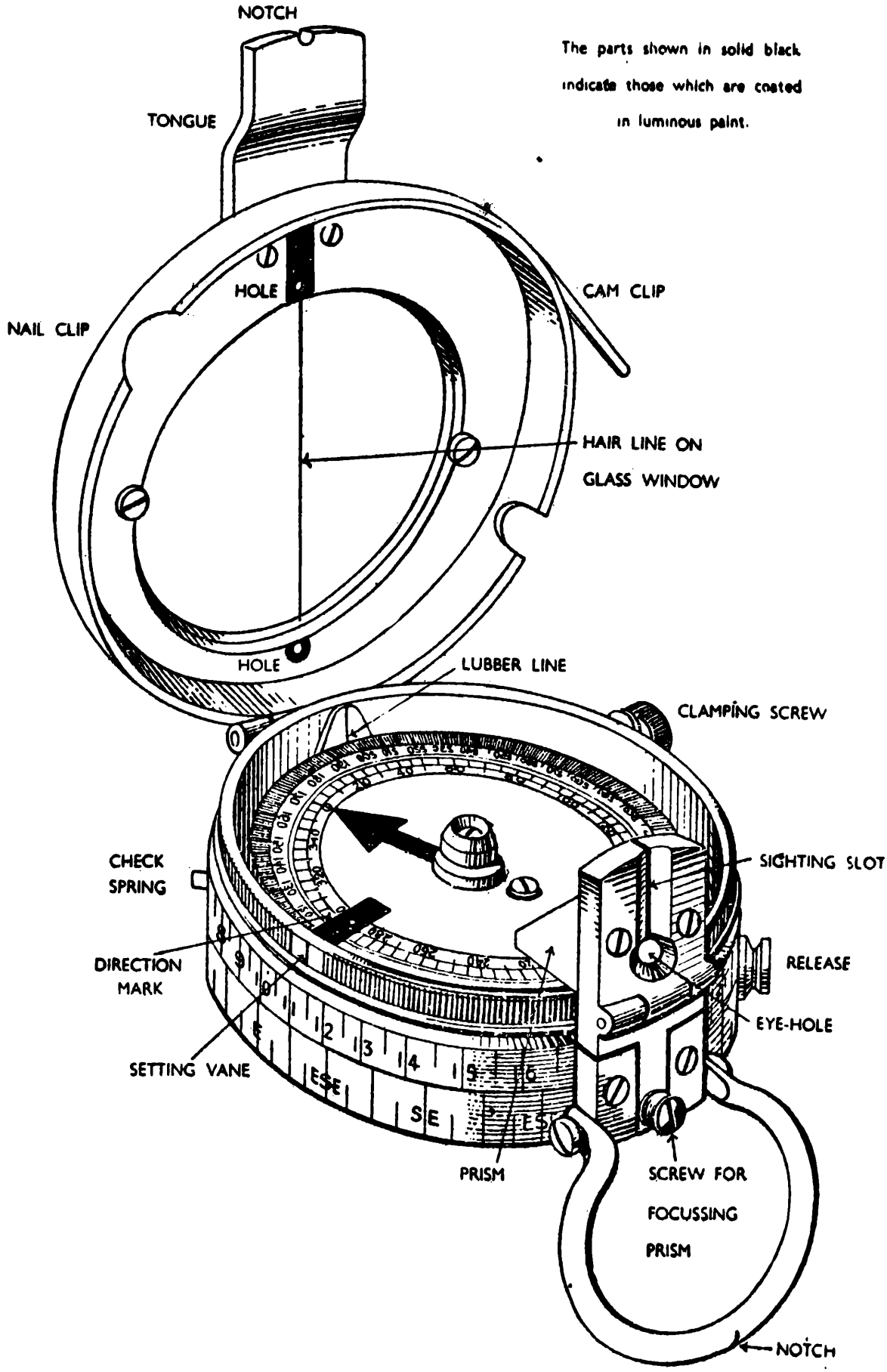


Fig. 14.
Service Prismatic Compass (Dry Type).

at the scale ; this is done by loosening the screw shown in the diagram and raising the prism as required.

To observe with the prismatic compass : Hold the ring with the left thumb, support the compass with the left forefinger, hold the right thumb against the check stop and the right forefinger on the small stud which operates a check spring to steady the swing of the needle. Bring the compass round so that, when viewed through the prism sighting slot, the hair-line is on the distant object which is being sighted. At the same time the outer graduated scale of the compass card can be seen through the eye-hole. To avoid having to wait until the card swings to rest, observe the extreme readings to which it is swinging at first, say 100° and 140°, and when the swing is about half through, i.e. at 120°, press the little stud to stop the card. Then release it and the swing will be much smaller. If necessary repeat the process over the smaller swing, and soon the needle will come to rest. Read off the number on the scale. With practice and with a steady hand this can be read to a quarter of a degree. (With the liquid prismatic compass, in which the needle and card float in a liquid composed of oil, glycerine and water, the card comes to rest much more quickly.)

(If the glass of the cover should be broken, so that there is no hair-line, a piece of thread or horsehair or any suitable material may be passed through the small hole at each end in the frame and made secure.)

6. BEARINGS.

Given that you have occupied a position A, and are required to make unit dispositions at distances from this point, it is vital to know the direction of movements proposed. For this purpose any one of three guides may be used, namely *true north*, *magnetic north* or *grid north*.

True North. This is the direction of the north pole from the point of observation.

Magnetic North. This is the direction towards which a compass needle points when it comes to rest. Compass needles are very sensitive to the presence of iron, and therefore it is necessary to exercise care in using them near possible sources of disturbance. Even a buried shell may affect accuracy. The War Office Manual of Map Reading details certain minimum *safe* distances for *visible* masses of iron. Broadly to summarise these, it may be said that no compass records accurately if it is used within a distance of 60 yards of heavy artillery units. Barbed wire, telegraph wires and field guns are disturbing elements from 10 to 40 yards, and even cap badges and steel helmets are effective obstructions up to 3 yards.

A simple test is to take a bearing of a distant object and then to walk, say 20 yards, towards it and take the bearing again. If there is no difference in the reading there is probably no concealed error. A second simple method is to take a bearing of a point B from a position of sight A, and a second bearing from B to A. The recorded bearing should differ by 180° if there is no hidden disturbance.

All compass needles, out of range of local attractions, will point towards the Magnetic North Pole. The position of this pole does not, excepting at rare intervals, coincide with the geographical or true north

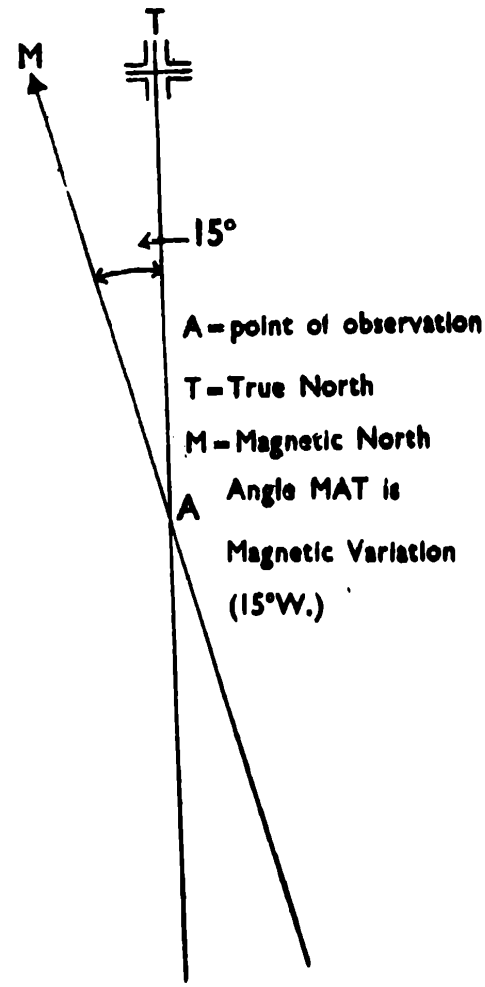


Fig. 15.

pole, but is situated west or east of it. At the moment in Britain it is about eleven degrees, fifty- one minutes, thirty seconds (11° 51′ 30″) west of true north, but this angle is decreasing at the rate of about six minutes yearly. If from a point on the earth's surface, say Greenwich, the true north is noted and an accurate compass is then used to record Magnetic North, it will be found to record the westward angle from True North noted above. This angle is known as the *Magnetic Variation.*

But few compasses are strictly accurate. Ordinary wear and tear will cause them to show faulty records. For example, instead of recording 11° 51′ 30″ a compass might show 12° 51′ 30″ or 10° 51′ 30″. In the former case it would be a *plus* error of one degree ; in the latter a *minus* error of one degree. This departure from a true record is known as the *Compass Error* ; and the angle between true north and the compass reading to an observed object is known as the *Compass Variation.* It follows that the error of the compass must be regularly observed. It is found as follows.

Assume that you are standing at a point A. AT is True North. AM is Magnetic North, and if your compass is correct it should point in the direction AM. But if it points to AC, then it is in error in that it records too much by the angle CAM. This is a plus error. If the compass points to AC′, it records too little by the angle C′AM. This is a minus error.

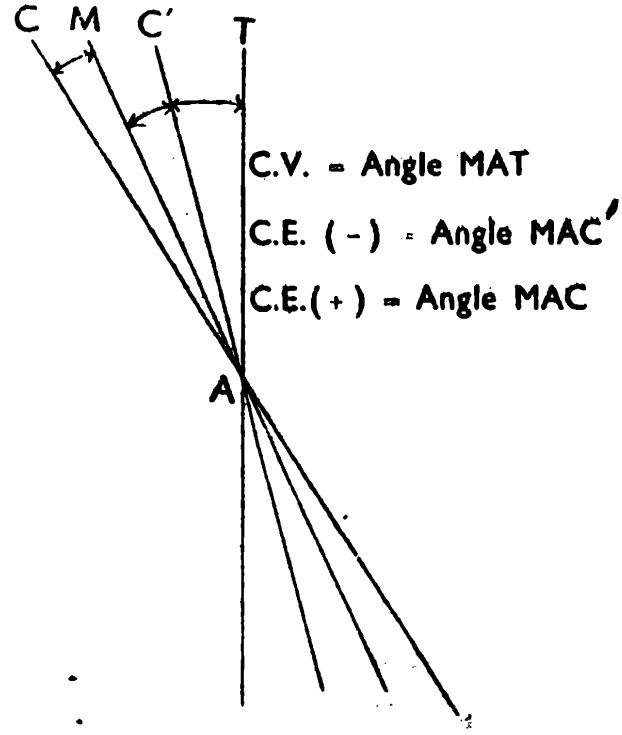


Fig. 16. Compass Variation and Error.

To discover the error, if any, sight from your position an outstanding distant object, recognizable on the map, and take its Compass Bearing, say 64°. Then with a protractor measure the True Bearing of the object on the map, say 50°. Then your Compass variation is 14° West.

Work out the Magnetic Variation. Suppose this is 11° West. Then your Compass Error is 3° West. Allow for this in all readings. Test your compass regularly and have it regularly adjusted.

Compass Variation = Magnetic Variation $\pm$ Compass Error.

To correct Magnetic Bearings to True Bearings and vice versa is a simple matter if the following rules are memorised :—

If the Magnetic Variation is west of True North :—

Magnetic Bearing equals True Bearing plus Magnetic Variation.

True Bearing equals Magnetic Bearing minus Magnetic Variation.

If Magnetic Variation is east of True North :—

Magnetic Bearing equals True Bearing minus Magnetic Variation.

True Bearing equals Magnetic Bearing plus Magnetic Variation.

But it is always wise to amplify by drawing a rough sketch which will show the angles involved.

Back Bearings.

Up to this point all bearings mentioned have been 'forward' bearings, i.e. the bearings of objects distant from the point of observation. Knowing these it is possible to march to any objective by either day or night. But having arrived at the destination and carried out whatever duty was

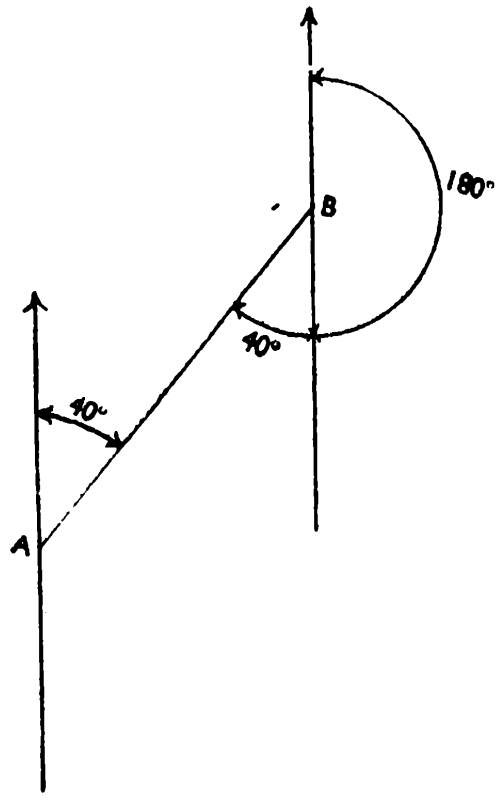


Fig. 17. Back Bearings.

required, one may be faced with the problem of returning to the base. It may not be possible to see the base from the forward object, and a direct compass bearing is thus impossible. But the difficulty is easily resolved.

Assume the base to be at A and the forward object to be a tower B, at a Magnetic Bearing of 40° from A. Then the bearing back from B to A is, as the diagram shows, 220°.

A simple rule is :—

If the *Forward* bearing is less than 180°, add 180° to it to get the *Back* bearing.

If the *Forward* bearing is more than 180°, subtract 180° from it to get the *Back* bearing.

Proceed in the same way for True bearings.

To Find True North.

(a) *By compass.* Place the compass on the map or paper and mark the direction in which the needle points. This gives the Magnetic North. Measure off the Compass Variation and so obtain True North. If the Compass Variation

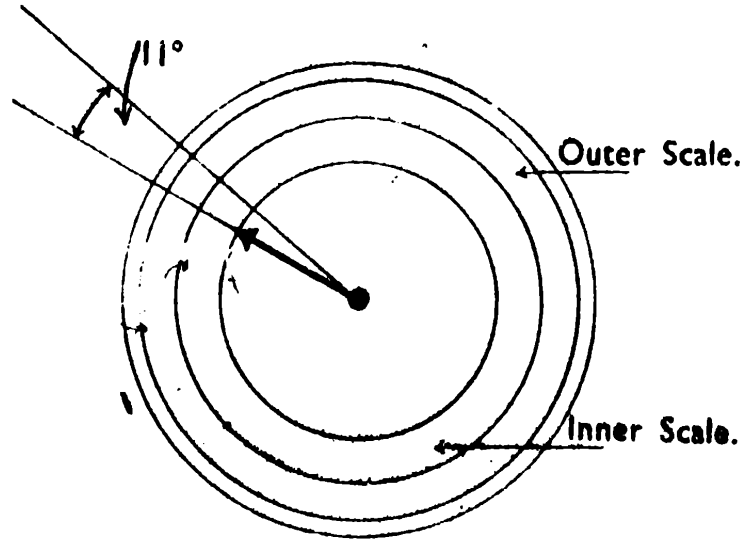


Fig. 18. Readings made on Inner Scale.

s, say 11°W., then True North lies 11° east of the direction aken up by the needle.

(b) *By a watch.*

Southern Hemisphere.

(1) **Point the Figure 12 at the Sun.**

(2) **Observe line from the centre of the dial to point of hour hand.**

(3) **Bisect the angle between the Hour hand and the figure 12, this gives you north.**

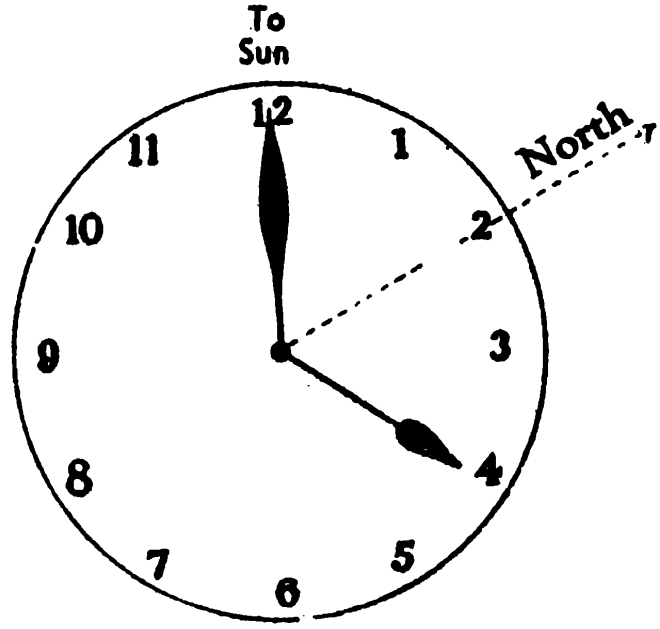


Fig. 19. Finding True N.—S. by Watch.

This method is useless in the tropics, where the sun is more or less overhead.

(See also later under "Setting of a Map" for a variation of Method (b).)

Grid North.

A grid is a network of squares superimposed upon a map. The lines which form these squares represent east and north

of an agreed starting point or origin. The sides of the squares are not perfectly east–west and north–south, but are nearly so. The latter series are known as Grid North lines.

Now all meridians or lines of longitude on a map approach each other as they are traced northwards from the Equator and meet at the North Pole. But since a 'grid,' to be useful, must be rectangular, it follows that its north–south sides do not approach but are always parallel. It is customary to select one meridian on a map and to arrange the grid so that one Grid North line coincides with this meridian. All other grid lines are parallel to this chosen one and make angles of varying amounts with True North.

The object of a grid is to make it easy to describe the position of a point upon a map. The following sketch illustrates the principle underlying the system.

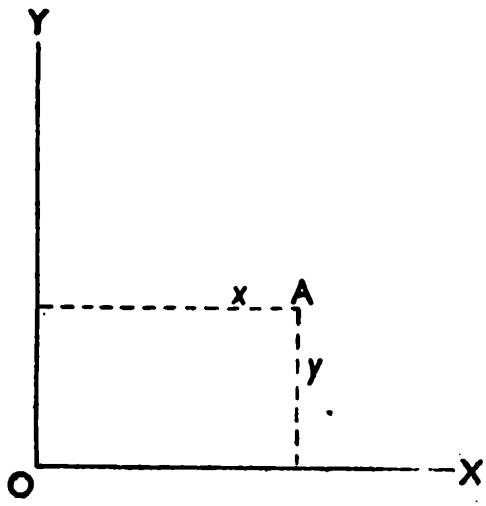


Fig. 20. Grid Location.

O is a reference point of known position, and from it are drawn two lines at right angles, OX and OY. The position of any point, say A, can then be referred to the known point, O, in terms of distances, x and y. x is termed an easting and y a northing.

The modern system of references is fully explained on every sheet issued by the Geographical Section, General Staff.

The variation of Grid North from Magnetic North is shown by diagram; as is the amount of departure of Grid North from True North. Full details of how to give a reference are provided, and the following example illustrates the procedure.

1. Note the number of the map sheet, printed in top right-hand corner, e.g. Sheet 138.

2. Ascertain from the "Relation of Grid Letters and Sheet Numbers" the correct letter to use, e.g. T.

3. Given a point T 137022.

   T represents the major square in which the point lies; 137 is its easting, reading from the west edge of the square—the line 13 is marked and the 7 represents 7/10 of the distance from line 13 to line 14. 022 is the northing and is read from the southern edge of square T. Again line 02 is marked, while the last figure 2 represents 2/10 of the distance between line 02 and line 03.

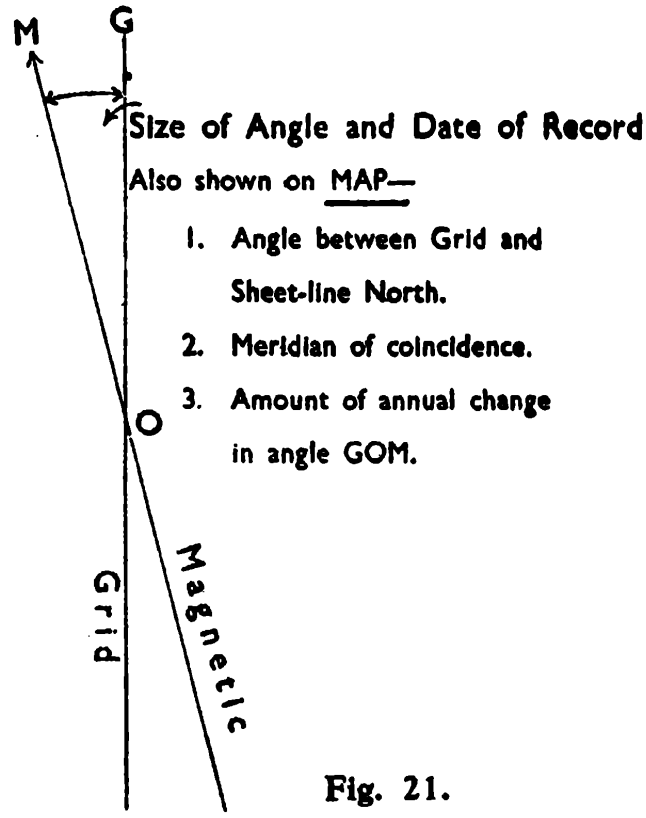


Fig. 21.

7. NIGHT MARCHING OR MARCHING IN REDUCED DAYLIGHT.

Marching by night or in conditions of reduced daylight, e.g. in mist or through wooded areas, demands a special technique. To meet such emergencies the compass is graduated around the outer brass ring into 360 degrees, numbered from the lubber line, which is zero, in an anti-clockwise direction. Every 10th degree is marked and numbered thus :

10 degrees by the figure 1, 20 degrees by the figure 2, and so on. The movable glass cover has a luminous ' director ' which can be set opposite to any required number of degrees on the brass ring.

Suppose it is required to move on a Magnetic Bearing of 30°. The procedure is as follows :—

1. Set the director to the 30° on the brass ring and clamp the glass cover.
2. Release the dial and turn until the luminous arrow points towards the director, which will then point towards Magnetic North.
3. The line of march is then along the sight of the two luminous patches and the hair-line of the outer cover.

The compass should be held close to the body to steady it, and with the outer cover opened out flat. The maintenance of correct direction is difficult with the ' dry ' or pinion Prismatic Compass, but fairly simple with the ' liquid ' variety, in which the dial plate revolves in a heavy fluid—a mixture of glycerine, alcohol and water.

It is always of great assistance to have a forward assistant who can proceed ahead on the required line until at the limit

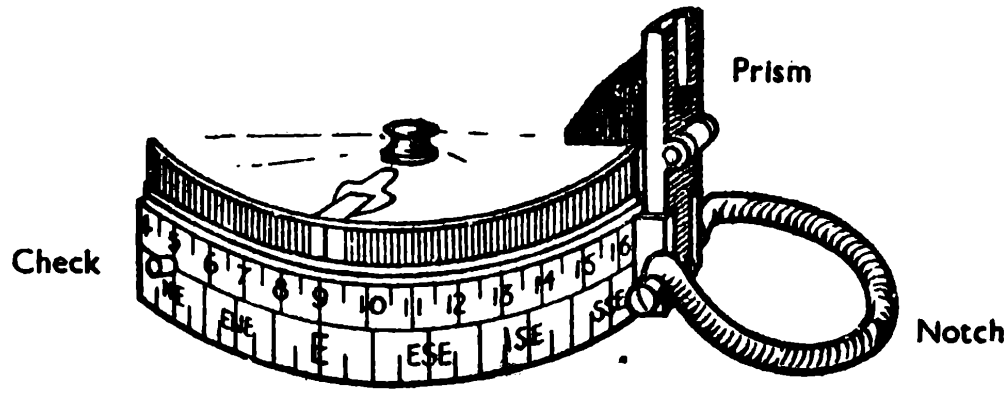


Fig. 22.
Compass (Side View)—for Night Marching.

of vision, where he can be halted by a prearranged signal—possibly a low whistle, a subdued torch flash, or a dial coated with luminous paint. If he is off the line of march it is necessary to move towards him on the correct line and then to repeat the operation. If the guide is supplied with a luminous stick or a muffled torch, greater speed of advance is possible.

Finally the compass bearer should arrange that either he himself or his guide should record the distance covered in terms of paces. In this aspect of the work it is of great value to study beforehand, and in full light, the required objective together with outstanding features on the route to be followed, e.g. woods, streams, etc. If this is done, distances can be previously measured on the map and greater certainty and accuracy thus assured.

It is possible to march by stars if they are visible. Select one at the outset, but remember that all stars move through the circle of 360° in 24 hours, i.e. 15° in one hour. Therefore a constant check, say once in every quarter of an hour, is necessary ; this involves calculating a fresh bearing.

8.

THE ORIENTATION OR SETTING OF A MAP.

A map cannot be used with accuracy until it is 'set,' i.e. held so that the north of the map points to the north of the ground which it represents. When this has been done, a line drawn from your position on the map to any object on the map should, if produced, pass through the actual object on the ground.

Further, it is necessary to set the map accurately if you wish :—

1. To locate your position, if not already known.

2. To add to the map details of the ground not already shown upon it.
3. To ascertain from your position the precise direction of objects observed in the field.

Methods of Setting.

These fall into two groups, namely those performed :—

(a) With a compass ; (b) without a compass.

With a Compass.

A. Lay the compass opened flat upon the magnetic north line so that the centre line (marked by the notches on ring and cover projection) coincides with it ; it may be necessary to produce the magnetic north line. Then turn the map, without moving the position of the compass, until the compass arrow points along the same line. The map is set. (See Fig. 23).

B. The true north line may be used in a similar way, but in this case the *Compass* Variation must be known. Proceed as in A, using the true north line, but continue to turn the map until the latter mark is opposite the number of degrees of variation indicated on the inner circle of the dial. (See Fig. 24).

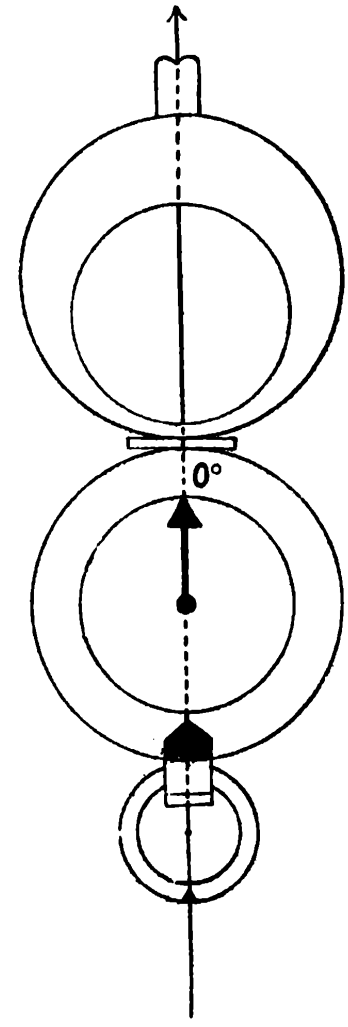


Fig. 23.
The Map is Set.

Without a Compass.

Several alternatives are possible, namely :—

1. *When position on the map is known*— say a spot A.

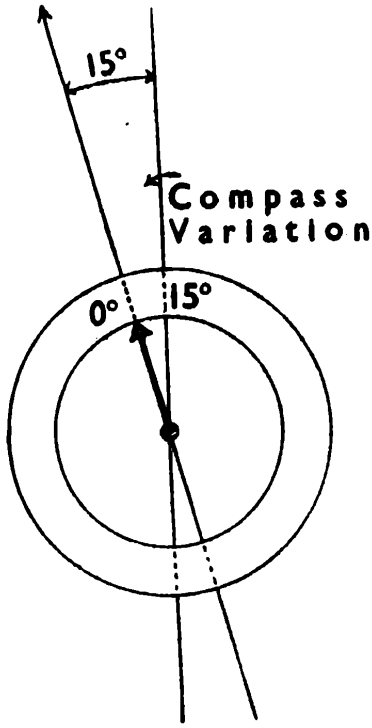


Fig. 24.
The Map is Set.

Identify on the map some distant object, B, which is visible on the ground. Draw a line on the map from your position at A to B, and turn the map until this line is directed towards the object on the ground which B represents. (See Fig. 25).

2. *When position on map is unknown.*

Identify on the ground two outstanding objects, A and B, shown on the map. Now place the map so that a line joining these two objects on the map is as nearly parallel as possible to the line which would join them on the ground.

In this method it is better, if practicable, for the observer to place himself between the two objects on the ground and to turn the map until the points observed and their representatives on the map are in a straight line.

A variation of this method is the identification of a stretch of road, rail, canal, etc., and the placing of the map so that the corresponding representations are parallel. It is obvious that many similar devices can be used, provided identification of objects upon the ground is possible and their representation upon the map exists.

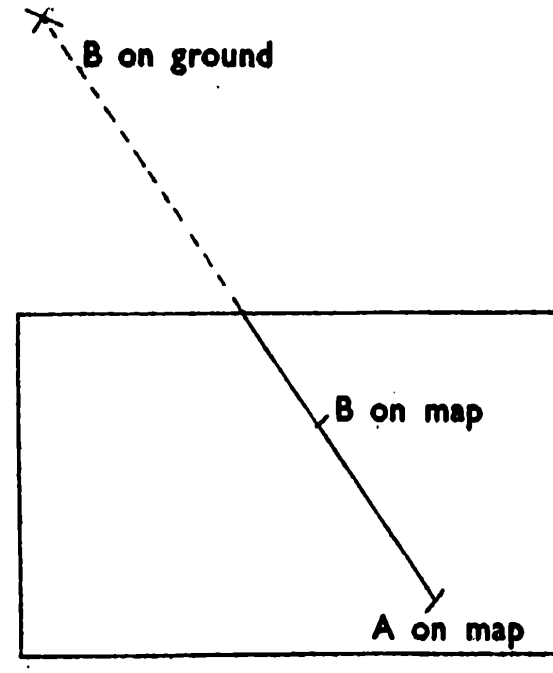


Fig. 25.
The Map is Set.

3. *Less accurate methods*

(a) *By the Sun.* The apparent movement of the sun around the earth is from east through south to the west—that is, in a clockwise direction. The complete revolution of 360° is accomplished in roughly 24 hours, but in this time the hands of a watch have moved twice round the dial. If therefore you point your watch at noon, when the sun is approximately due south, towards the sun in such a way that the

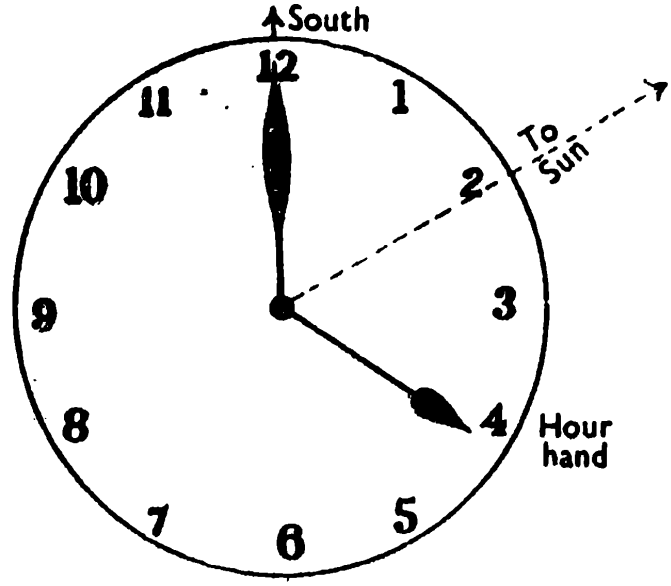


Fig. 26. Setting by Sun.

hour hand is directed towards the sun, then by 4 o'clock the hour hand will have passed through 60°; but the sun, moving only half as fast, is in the direction of 2 o'clock. Therefore, if at any time you hold your watch so that the sun is halfway between the hour hand and 12 o'clock, then the 12 o'clock line points to the south.* This is only a rough setting owing to irregular daily and seasonal relations between the earth and the sun.

A method based upon the same principle involves the use of the map and a protractor. Assuming the sun to be approximately south at noon, then by 4 o'clock it will be, in

*In the Southern Hemisphere point 12 o'clock at the sun. North then lies halfway between the HOUR hand and TWELVE.

the northern hemisphere, 60° west of south. Draw a south-north line on the map and set off from any point on that line an angle of 60°. Direct this line towards the sun and the map is set. (Always remember to allow for summer time.)

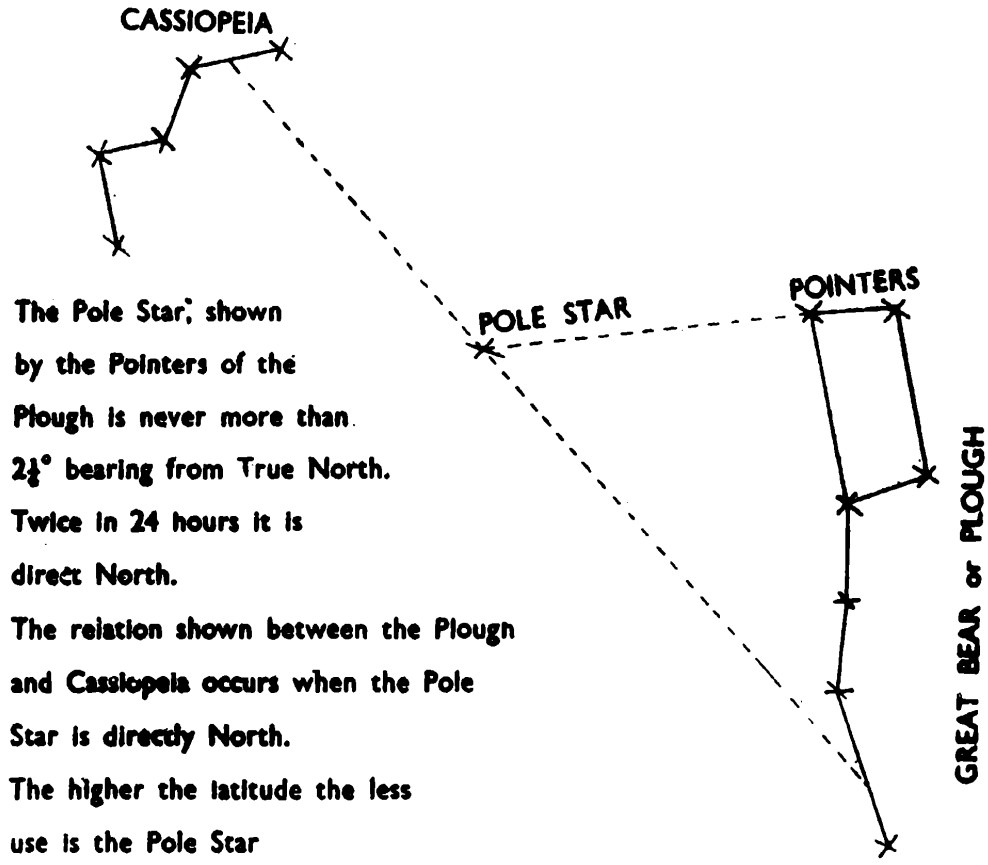

CASSIOPEIA
POLE STAR
POINTERS
GREAT BEAR or PLOUGH
The Pole Star, shown by the Pointers of the Plough is never more than 2¼° bearing from True North. Twice in 24 hours it is direct North.
The relation shown between the Plough and Cassiopeia occurs when the Pole Star is directly North.
The higher the latitude the less use is the Pole Star

Fig. 27. Map Setting.
To find the True North by Stars.

(b) At night, if the stars are visible, the Pole Star may be found from the 'Pointers' of the Great Bear. The Pole Star is never more than 2° from due north, and the relation between the Great Bear 'Pointers' and the constellation of Cassiopeia, directly opposed to it, can be used to determine the exact north.

Resection, or Finding Position on the Map.

Given a detailed map, the major features of hills, valleys, roads and settlement provide a general indication of position

which must be exactly identified from the lesser facts shown on the map, e.g. paths, farm fences, copses, etc. It is not always wise to use as guides road junctions, since maps may be several years old and may therefore fail to record by-pass routes and other new features. Railway lines are relatively more permanent. When identifying position from these, it is possible to use even the steam or smoke from an engine to place the route of a line otherwise invisible.

But the most accurate method of finding one's position is that known as *Resection*. Several ways of carrying this out are possible, but not all will be considered here.

Method 1. Lay the map on a horizontal surface and set it as accurately as possible, using the compass.

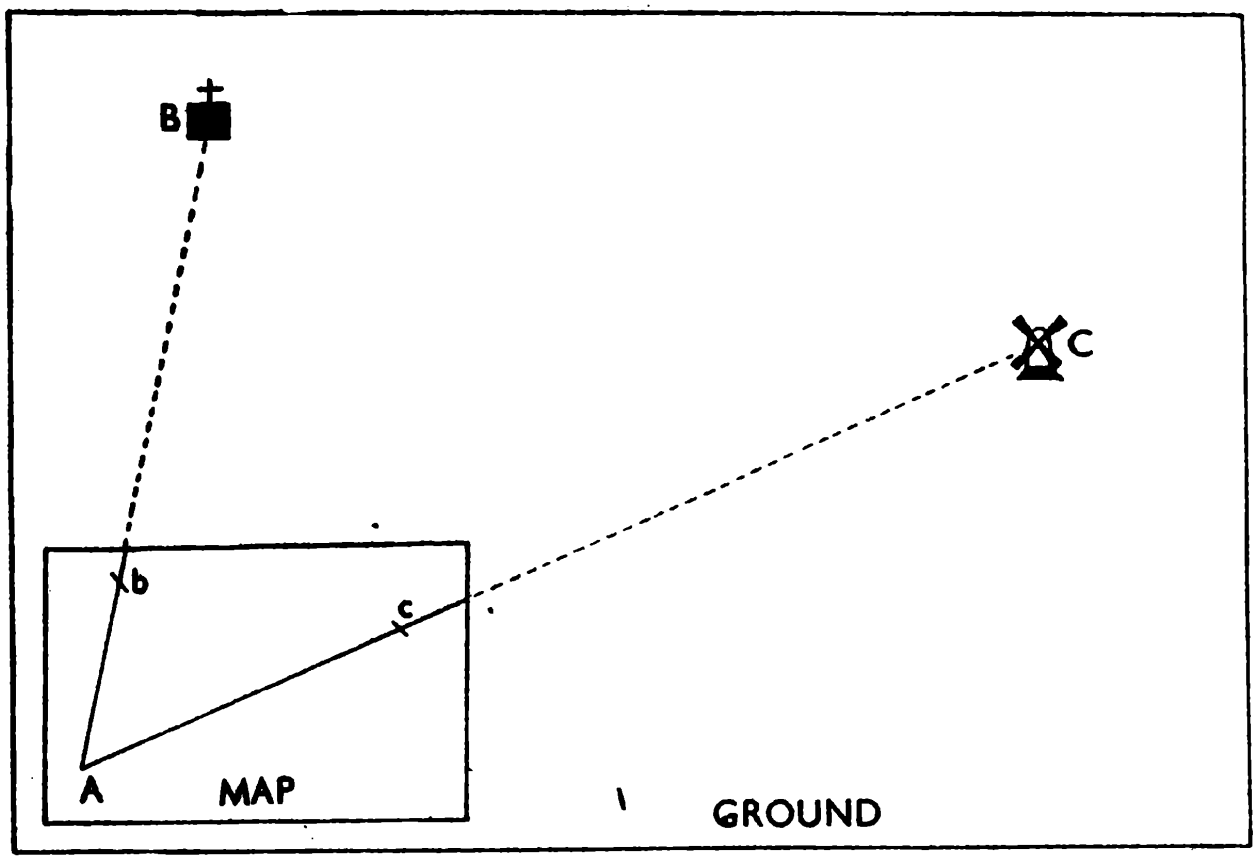


Fig. 28.
A = Resected Position on Map.
B = Church ('b' on map).
C = Windmill ('c' on map).

Identify on the ground two prominent objects, the conventional signs for which can be recognised on the map—say a church tower and a windmill. Draw a pencil line through each symbol in the correct direction of the object it represents. Produce these rays backwards until they meet. The point of intersection is the position occupied.

A check should be established by selecting another prominent feature, natural or artificial, and proceeding similarly. Within a small margin of error this third ray should pass through the position already found. Should the error be large, it is probably accounted for by the fact that the map is not set accurately, or one of the objects has been wrongly identified. Some help may be obtained by comparing the local details, woods, buildings, cross-roads, etc., shown on the map, with the ground about the observer.

Method 2. The principle of this method is based upon the use of back bearings.

Identify two objects on the ground, A and B (a and b on the map). Take compass bearings of each.

Plot on the map from a and b the bearings taken of them with a reversed Protractor and produce the rays backwards. The point of intersection fixes the position of observation.

It is obvious that the result can be obtained by actual calculation of the magnetic back bearings, or, if the compass variation is known, the true back bearings.

9.

ENLARGEMENT AND REDUCTION OF MAPS.

By itself the enlargement of a map adds nothing to the information given on the original, but it may be useful in two ways :—

1. As a basis for the addition of details later on, details obtained from either reconnaissance or photographs.

2. As a basis for the addition of notes and descriptions.

Method. In the field it is difficult to use instruments specially made for the purpose, so the method normally employed is to enlarge by eye, that is, to transfer the detail inside a simple geometrical shape (the square and the triangles formed by drawing the diagonals of a square) on the original map to similar shapes enlarged the requisite number of times. If the original map is already divided into small squares, diagonals only need be drawn ; if it is not, squares must first be drawn upon it.

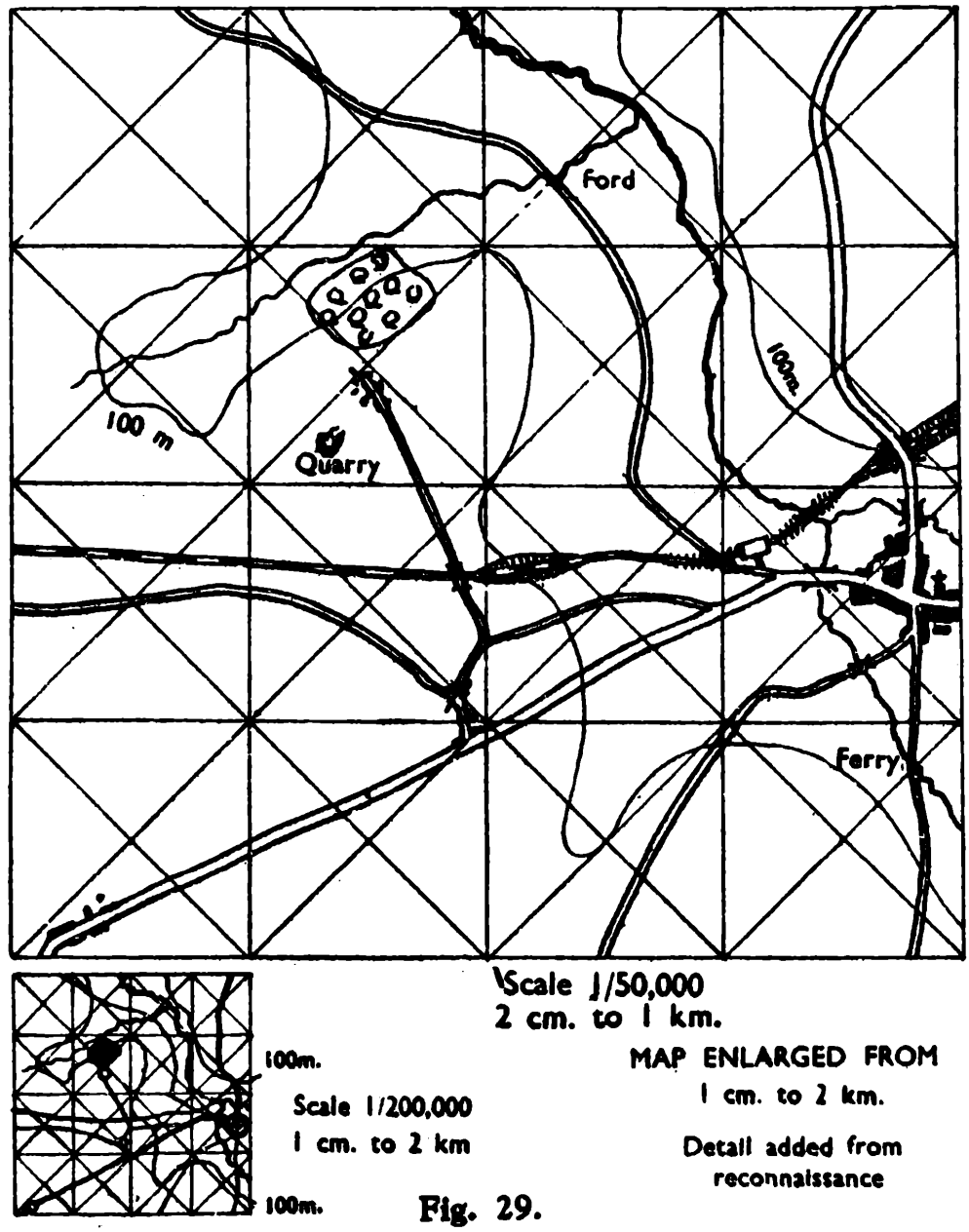


Fig. 29.

Examples.

1. To enlarge a section of a ¼" to the mile map to a 1" to the mile scale. The enlargement will have to be four times the original. With every 2" square required, subdivide it into ½" squares ; draw a main square 8" in side and subdivide into 2" squares ; add diagonals to the original and to the enlargement and copy the detail by eye.

2. To enlarge a section of the French 1/200,000 to 1/50,000. The enlargement will have to be four times the original. The original in this instance is not squared. On it draw kilometre squares ; draw 4 km. squares for the enlargement, add diagonals to both and copy the details by eye.

On the finished enlargement enter its scale and the scale of the original ; indicate the source of the information which is added later, e.g. reconnaissance or photographs.

Reduction. If reduction of maps should be necessary, the opposite procedure is required.

10. PANORAMA AND LANDSCAPE SKETCHING.

A drawing of a piece of country may be valuable in three ways :—

1. As an amplification of a map.
2. As an addition to a report.
3. As a substitute for a map when no map is available.

Method.

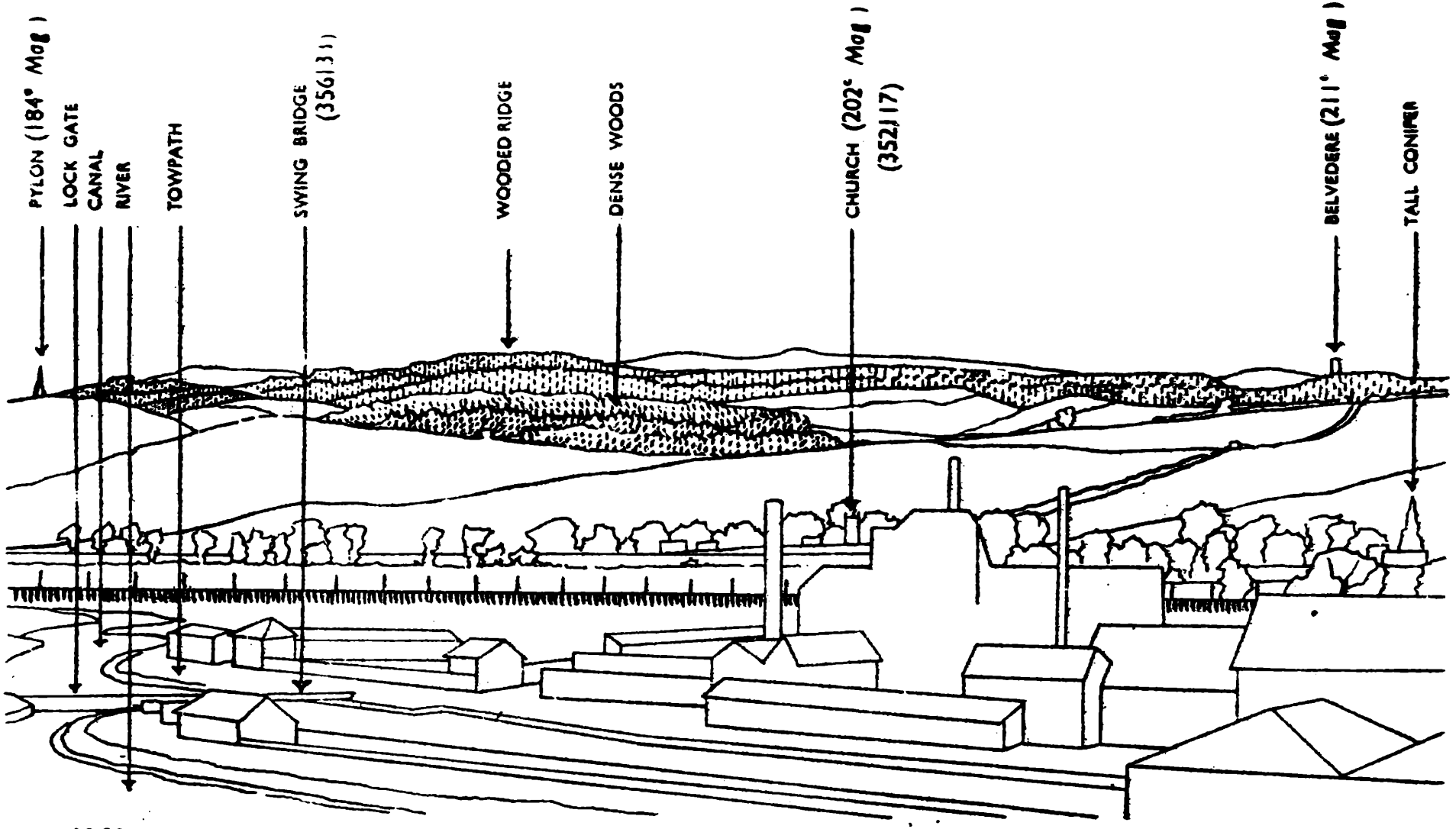
First of all study the country with the naked eye and with field glasses, noting the main undulations of the ground and how they run in front of and behind each other ; the main features of the vegetation, either woods or prominent hedges

and single trees ; and the principal artificial objects like roads, railways and buildings.

The rules of perspective must be followed, i.e. all parallel lines like railway metals or the sides of a road must be shown approaching each other as they get nearer the horizon. Extreme simplicity must be the aim, and woods, buildings, etc., must have the simplest outline which will suffice for them to be recognizable ; shading should be employed only to distinguish a wood. Use a hard pencil, say " H," to secure a clear, firm line.

Sometimes the immediate requirements of the situation dictate the extent of country to be included ; if this is not so, it is generally found that a stretch of country with a maximum horizon arc of 30° is sufficient. The Military Manual suggests that if a Service protractor be held 11 inches from the eye, it will obscure country having an horizon arc of 25° (or it 'subtends' an angle of 25°). If the protractor be held a little nearer it will cover 30° of horizon. The same authority recommends that the protractor should be kept exactly at a constant distance from the eye of the observer by means of a piece of string, one end of which is attached to the protractor and the other end held between the observer's teeth, the distance being 11 inches for an horizon arc of 25°

For the purposes of this kind of drawing, minor folds in the ground and any other topographical details require to be shewn very clearly, so that the vertical scale must be exaggerated, a suitable ratio being 2 : 1, i.e. in inserting details their vertical relations should be doubled each time. (By " vertical " measurements in panorama drawings is meant not height above sea level, as is usually understood, but measurements from the bottom of the finished drawing to the horizon, i.e. from the position of the observer to the horizon of the country which is being drawn.)



10.30 *a.m.*

20th November, 1939

Sky partially clouded

Visibility fair

PANORAMA FROM HILL

T.(355136)

M. Kolle

The sketch can be drawn (a) by eye only, so that the horizontal and vertical positions of every feature are estimated : this method should be used only if time is short ; (b) by using the graduations on the edge of the protractor, held in front of the eye, to measure the horizontal position of features, and then placing the protractor on the paper and marking off the distances. Vertical proportions may be measured similarly by holding the protractor in a vertical position so that the short edge touches the horizon. (Care should be taken to ensure that the protractor is held at a constant distance from the eye —see above remarks.) In increasing the vertical proportions of the landscape by two, it will be observed that the varying length of each division on the edge of the protractor introduces a complication. Suppose that the brow of a hill below the horizon is found to appear on the edge of the protractor at the mark 50° : on the sketch the distance of twice this amount, at which the hill is to appear below the horizon, should be obtained by marking off the protractor distance on the paper and then repeating it. (Distance, and not numbers of degrees, must be used.

After the framework of the sketch has been completed, fill in the detail and draw the lines more heavily, so that they are darker and heavier as they approach the foreground. Detail should be shown as follows :—

Woods, usually in outline only and lightly shaded by lines.

Trees, where outstanding, should appear in outline only.

Rivers, a double line diminishing in width as it recedes.

Roads, also a double line, as with a river but smoother.

Railways, in the foreground a double line with small cross lines ; in the background a single line with short vertical strokes to indicate telegraph poles.

Church, enough outline to show if it has a tower or spire.

Towns and Villages, small rectangular shapes for houses, with some indication of towers, factory chimneys, large buildings, etc.

Complete the panorama by entering the map reference of the observer's position and the bearing of the central point; write the names of all important points shown on the sketch, together with bearings and, if possible, map references, along the top of the sheet and draw lines from the names to indicate the position of the points shown on the sketch; add the date, time and a brief description of the weather conditions.

Two other methods, which take longer but are of greater accuracy, are suggested by the Military Manual. :—

1. In a piece of cardboard cut a hole the size of a Service protractor, and paste over it a piece of any transparent material like tracing paper which has a $\frac{1}{2}$" grid ruled on it. If the sketch is drawn on a similar grid the detail can be transferred square by square. (The squares on the drawing paper must be doubled in depth, to produce rectangles so as to double the ratio of vertical to horizontal.)

2. Some help may be obtained in fixing the position of features by taking their bearings with a compass, but this method is a slow one.

Panoramas for Artillery Use.

The panorama may be developed so as to be of value to an artillery unit. For this purpose a central line is drawn through some outstanding point; then, usually by means of a compass, horizontal angles of a constant amount, usually 2°, are measured to the right and the left of the central line. At some convenient distance above the horizon a horizontal line

is drawn, and from the intersection of this line and the 2° bearings verticals are drawn. The angles of sight to probable targets and other necessary data are then added in the form of a table.

Such panoramas for the use of artillery serve three purposes :—

1. They are a means of reporting to a battery commander the view which can be seen from an observation post.

2. They are an aid to an artillery commander in indicating targets for observed fire to his battery commanders.

3. They serve as a record of data on a battery front.

APPENDIX.

JUDGMENT OF DISTANCE.

Although instruments designed to assure accurate judgments of distances exist, it is often necessary to make estimates by eye. There is no easy road to skill in this difficult task, but constant practice, aided by an intelligent application of certain rough rules, can be of great help. Some lengths, e.g. that of a cricket pitch—22 yards ; a football pitch—120 yards, are well-known. The various distances on a rifle range should be studied and recorded in the memory. It is always useful to remember that 110–130 walking paces cover about 100 yards. The height of the individual, his length of pace and rate of progress determine the exact relation between number of paces and distance travelled. You will always find that there is a tendency to place distant objects farther away than they actually are ; only experiment can guide you upon the amount of allowance which must be made.

Since no two observers have the same eyesight, you must make your own chart of distance if you wish to make a 'Distance Chart.' One of the most useful approaches to such a chart is to go into the field with a fellow observer, and record some or all of the following details :—

At what distance do you fail to distinguish :—

(a) The details of his body, e.g. face, head, shoulders, hands, etc. ?

(b) Details of clothing, e.g. buttons, badges, pocket flaps, etc. ?

(c) Movement of body or limbs ?

(Always record your observations with careful reference to lighting, i.e. whether sun is in front or behind your point of observation, whether sky is clear or clouded, etc.)

Aids to Judgment.

1. On a normally clear day a man at 500 yards appears like a fixed object—his movements of limbs cannot be observed.
2. Beyond 100 yards you cannot distinguish details of uniform nor can you recognise hands.
3. Always under-estimate distance unless you are dealing with large objects or objects with the sun behind them.
4. Broken ground tends to make you over-estimate, as does a view of an object which 'melts' into its background. It is a good rule to allow 10 per cent for possible over-estimation.
5. Make it a rule to keep constant observation upon the appearance of common objects, e.g. churches, telegraph poles, pylons, railways and roads at varying distances.

Under normal conditions the following chart may be a guide :

Face. Details recognisable at 300 yds.

Hands. Details and movement recognisable at 100 yds.

Uniform. Details and movement recognisable at 100 yards.

Standing Object (size of a man). Recognisable at one-quarter of a mile. (If lying down, the distance is reduced by one-third.

But forward observation of distance must be aided by judgment of lateral distance ; both estimates may be helped by practice efforts with the fore and back sighting vanes of a rifle. The value of these is a matter of your eyesight and experience. Nevertheless there are certain other aids. Apart from taking bearings of forward objects, the observer's arm and hand are great helps ; briefly their use may be summarised thus :—

1. Hold the hand—fingers and thumb thoroughly extended—at arm's length. The span, from tip of thumb to tip of little finger, is about 18°.

2. Hold the hand—fist clenched and knuckles upwards—at arm's length. Then the total span from the outside of the first finger to the outside of the little finger covers about 8° ; between the middle of the forefinger knuckle and the middle of the second knuckle is 3° ; between the middle of the second and third and fourth knuckles is 2° in each case.

3. Hold the fist partially clenched but with the little finger extended fully when held at arm's length. The breadth of the tip of the little finger covers an angle of 1°.

It must be remembered that these methods are approximations, and should therefore be tested out on all possible occasions before they are used in the field ; it is also wise to experiment upon camouflaged objects for, when distinguished, their outlines are so indistinct that they confuse accurate judgment.

Finally, it is worth while to draw attention to the various cheap but useful range-finders on the market ; the writers, however, recommend personal estimates of distance based upon the experience gained by constant practice.

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